Review Article (Open access)

# Phytochemical and Pharmacological Significance of Genus: *Impatiens*

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**ABSTRACT-** The genus *Impatiens* (*Compositae*) was reviewed for its chemical constituents and biological significance and its traditional uses. The genus has been known for its various biological activities like: antimicrobial activity, antioxidant activity, antiallergic activity, antipruritic activity, antidermatitic activity, transcriptional activity, anti-rheumatoid arthritis activity, anti-histamine activity, testosterone 5α-reductase inhibitory activity, cyclooxygenase-2 inhibitory activity and anti platelet activating activity. Most of the plants of this genus are rich sources of napthoquinones, flanonoids, glycosides and sapogenins. The bioactive constituents or plants extracts may be uses for treatment of various diseases and these would be used as a new formulation for the novel drugs discovery in pharmaceutical industries. This review presents comprehensive information on the chemistry and pharmacology of the genus together with the traditional uses of many of its plants. In addition, this review discusses the structure-activity relationship of different compounds as well as recent developments and the scope for future research in this aspect.
**Key-words-** *Impatiens*, Antiallergic, Antipruritic, Antidermatitic, 2-Methoxy-1,4-Napthoquinone, Flavonoids

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## INTRODUCTION

*Impatiens sulcata* Wallich in Roxb. (Balsaminaceae) syn. *Impatiens gigantea* Edgew is an annual or biennial herb 50 to 250cm high, found in North-West Himalayas. It is hairless and similar to Himalayan balsam. Its leaves are generally rounded teeth and not acute as Himalayan balsam Fruit is linear where as it is club-shaped and flowers are pink, purple with darker spotted sac like lower sepal.

## TRADITIONAL USES

*Impatiens sulcata* Wallich in Roxb. (Balsaminaceae) is a medicinal plant used in folk medicine for treatment of several ailments. In traditional medicine, most of the plants belong to the genus *Impatiens* has been used to treat a wide variety of ailments such as treatment of articular rheumatism, bruises, beriberi.

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It is used for antimicrobial, antirheumatic, antipruritic and antitumoural purposes as well as for the treatment of difficult labour and puerperal pain. The seeds of *Impatiens balsamina* have been used to treat difficult labour, to suppress puerperal pain, expectorant, to act as an emmenagogue, and as an antidote for poisoning from fish in some countries (Ching S et al., 1977; Perry LM et al., 1980). In Thailand, *Impatiens balsamina* has traditionally been used for the treatment of thorn or glass-puncture wounds, abscesses, ingrown nails and chronic ulcers caused by allergic reaction of detergents (Fransworth NR et al., 1992). The aerial parts of *Impatiens balsamina* are used in Chinese herbal medicine to treat articular rheumatism, beriberi, bruises pain and swelling (Su J et al., 1997).

In some areas of Japan, juice squeezed from the white corolla of *Impatiens balsamina* is painted topically on the skin as an antipruritic to treat several types of dermatitis including urticaria, antianaphylactic (Ishiguro K et al., 1992; Ishiguro K et al., 1994; Fukumoto H et al., 1996); antihistamine (Fukumoto H et al., 1995); antipruritic (Ishiguro K et al., 1997; Ishiguro K et al., 1998); anti-platelet-activating factor (Oku H et al., 1999); anti-dermatitic (Oku H et al., 2001). Traditionally, the dried herb is either boiled in water to make a tea used to treat systemic bacterial and fungal infections or applied directly on the skin or nails in a plaster form to treat local infections (Yang X et al., 2001).

The plants is traditionally used in scrofulosos, carbuncles, dysentery (Kang SC et al., 1992); isthmus and crural aches, fractures, superficial infections, fingernail inflammation (Jiang S et al., 2003); tumor, difficult labor and puerperal pain (Yang X et al., 2001); and as emetic, cathartic, diuretic, and for pain in the joints (Ghani A, 2003). Ayurvedic system of medicines describes the oil of the plants *Impatiens scabrida* to be used as a semidrying oil (Yadawa NR et al., 1992); whole plant of *Impatiens textori* has been used for detoxication and treatment of carbuncle and contusion in Chinese medicine (Chang S et al., 1977). It is also used for decreasing the blood pressure and inflammation (Ueda Y et al., 2005). Aerial parts of *Impatiens emirnensis Bak* are used as antimalarial remedy in Madagascar (Rasoanaivo P et al., 1992). Rhizomes of *Impatiens pritzellii* were used as a traditional treatment of rheumatoid arthritis, diarrhea, and acute abdominal pain (Wan DR et al., 1989). *Impatiens siculifer* were used traditional Chinese medicine in the treatment of rheumatoid pain and paralysis, burns, scalds, and fractures (State Administration of Traditional Chinese Medicine, 1999).

*Impatiens parviflora* has been widely used in traditional medicine in Asia to treat rheumatism, fractures, infection and in some area of China people ingest this plant as a vegetable or use as anti-cancer herb (Ding ZS et al., 2008). In America *Impatiens capensis* has been used to treat hives, and rashes caused by other plants (Henn RL, 2008). It is also used to prevent poison ivy rash by rubbing it on the skin prior to known exposure or immediately after coming in contact with poison ivy (Foster S et al., 1990).

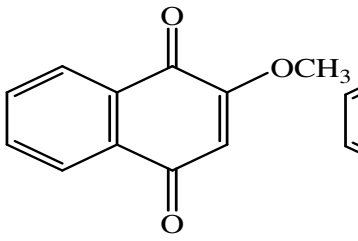
## CHEMICAL CONSTITUENTS

The plants of the genus *Impatiens* contain various types of secondary metabolites including terpenoids, steroids, flavonoids, napthoquinones and many others. The plants and their chemical constituents have been summarized below and the chemical structures of various compounds isolated from different parts of genus *Impatiens* are drawn in Figures 1-91.

### *Impatiens balsamina*

2-methoxy-l,4-naphthoquinone (1) (Panichayupakaranant P et al., 1995; Fukumoto H et al., 1996; Ishiguro K et al., 1997; Isiguro K et al., 1998; Oku H et al., 1999; Yang X et al., 2001; Oku H et al., 2002; Ding ZS et al., 2008; Mori N et al., 2011; Wang YC et al., 2012; Sakunphueak A et al., 2013); lawsone (2-hydroxy-1,4-naphthoquinone) (2) (Panichayupakaranant P et al., 1995; Fukumoto H et al., 1996; Ishiguro K et al., 1997a; Ishiguro K et al., 1997b; Oku H et al., 1999; Oku H et al., 2001; Ishiguro K et al., 2002; Motz VA et al., 2012); kaempferol (3) ( Fukumoto H et al., 1996; Ishiguro K et al., 1997a; Ishiguro K et al., 1997b; Lim YH et al., 2007); kaemferol-3-O-glucoside (4) (Fukumoto H et al., 1996; Ishiguro K et al., 1997a; Ishiguro K et al., 1997b; Oku H et al., 1999); kaempferol-3-O-rutinoside (5) (Fukumoto H et al., 1996; Ishiguro K et al., 1997a; Ishiguro K et al., 1997b; Oku H et al., 1999; Oku H et al., 2001; Ishiguro K et al., 2002); kaempferol 3-rhamnosyldiglucoside (6) (Fukumoto H et al., 1996; Ishiguro K et al., 1997a; Ishiguro K et al., 1997b; Oku H et al., 1999); kaempferol-3-O-β-D-glucopyranoside (7) (Mori N et al., 2011); 7-hydroxy-6-methoxycoumarin (scopoletin) (8) (Panichayupakaranant P et al., 1995; Oku H et al., 2002); impatineol (9) (Ishiguro H et al., 2000; Oku H et al., 2002a; Oku H et al., 2002b); quercetin (10) (Fukumoto H et al., 1996; Ishiguro K et al., 1997; Oku H et al., 1999; Lim YH et al., 2007); quercetin-3-O-glucoside (11) (Oku H et al., 1999); quercetin-3-O-rutinoside (12) (Fukumoto H et al., 1996; Ishiguro K et al., 1997; Oku H et al., 1999); di-(2-hydroxy-1,4-naphthoquinone-3)-methane (13) (Panichayupakaranant P et al., 1995; Fukumoto H et al., 1996); balsaminone A (14), balsaminone (B) (15), balsaminone A acetate (16) (Ishiguro K et al., 1998); spinosterol (17), isofraxidin (18) (Panichayupakaranant P et al., 1995); 2,3-dihydroxy-1,4-naphthoquinone (19), 2-hydroxy-3-methoxy-1,4-naphthoquinone (20), p-hydroxybenzoic acid (21), p-coumaric acid (22), furulic acid (23), 2,2'-methylenebis(3-hydroxy-1,4-naphthoquinone) (24) (Oku H et al., 2002); 2-hydroxy-3-(2-hydroxyethyl)-1,4-naphthoquinone (25) (Oku H et al., 2002a; Oku H et al., 2002b); impatienolate (26), balsaminolate (27) (Oku H et al., 2002 ); hosenkol B 3-O-β-D-xylopyranosyl (1→2)-β-D-glucopyranosido-26-O-β-D-glucopyranoside (28), hosenkol C 3-O-β-D-xylopyranosyl(1→2)-β-D-glucopyranosido-28-O-β-D-glucopyranoside (29), hosenkol B 3-O-β-D-xylopyranosyl(1→2)-β-D-glucopyranoside (30), hosenkol B 3-O-β-D-glucopyranosido-26-O-β-D-glucopyranoside (31), hosenkol A 3-O-β-D-glucopyranosyl(1→2)-β-D-glucopyranoside (32), hosenkol A 3-O-β-D-glucopyranosyl(1→2)-O-β-D-glucopyranosido-26-O-β-D-glucopyranosido-28-O-β-D-glucopyranoside (33), hosenkol A 3-O-sophorosido-28-O-glucoside (34), hosenkol D 3,28-O-diglucoside (35), presapogenin (IV) hosenkol A 3-O-β-D-glucopyranoside (36) (Shoji N et al., 1994); presapogenin (II) (hosenkol C 3-O-β-D-glucopyranosido-28-O-β-D-glucopyranoside (37), presapogenin (III) (hosenkol C 3-O-β-D-glucopyranoside (38), presapogenin (I) (hosenkol B 3-O-β-D-glucopyranoside) (39), hosenkol A (40), hosenkol B (41), hosenkol C (42) (Shoji N et al., 1994a; Shoji N et al., 1994b); hosenkol A 3-O-β-D-xylopyranosyl (1→2)-β-D-glucopyranosyl-28-O-β-D-glucopyranoside (43), hosenkol A 3-O-β-D-xylopyranosyl(1→2)-O-β-D-glucopyranosyl-26-O-β-D-glucopyranosyl-28-O-β-D-glucopyranoside (44), hosenkol D 3-O-β-D-glucopyranosyl(1→2)-β-D-glucopyranosyl-28-O-β-D-glucopyranoside (45), 24R/25R hosenkol A (46) (Shoji N et al., 1994); flavonoid-3-β-D-glucosidases (Boylen WC et al., 1969).



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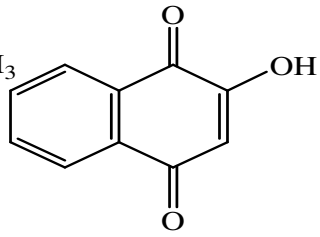

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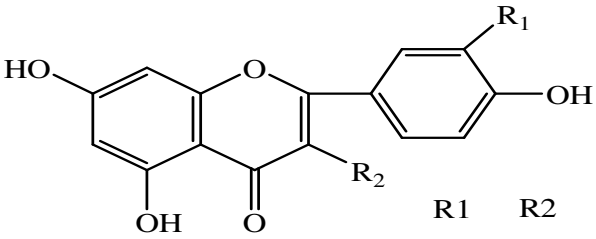
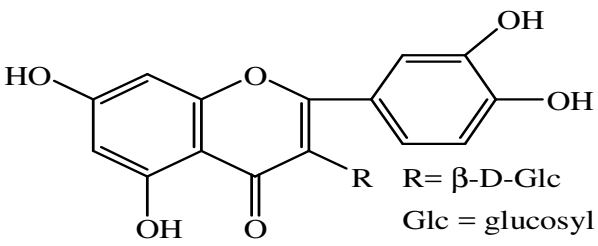


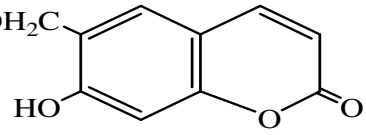
| | R1 | R2 |
|---|---|---|
| 3 | -H | -OH |
| 4 | -H | -O-Glc |
| 5 | -H | -O-Glc-Rha |
| 6 | -H | -O-Glc$^2$-Rha |
| 10 | -OH | -OH |
| 11 | -OH | -O-Glc |
| 12 | -OH | -O-Glc-Rha |

Glc = glucosyl
Rha = rhamnosyl



R= β-D-Glc
Glc = glucosyl

7



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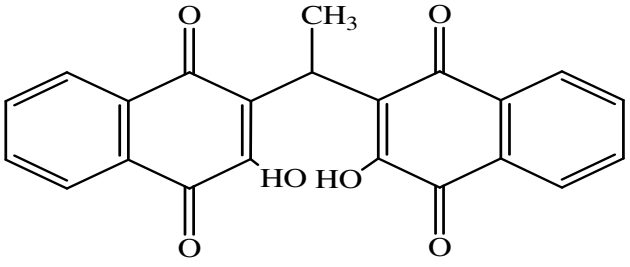

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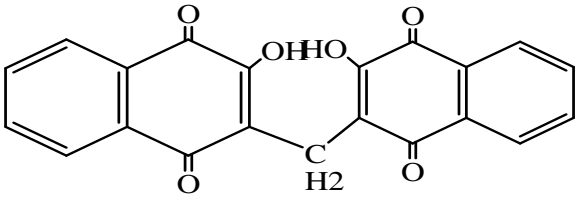

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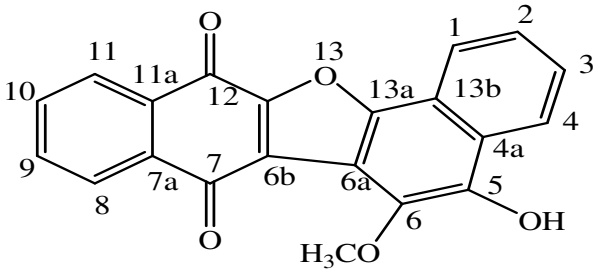

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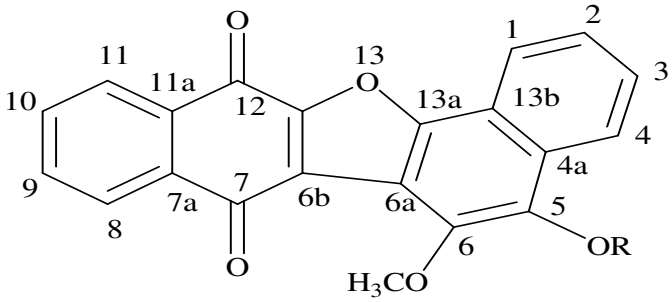
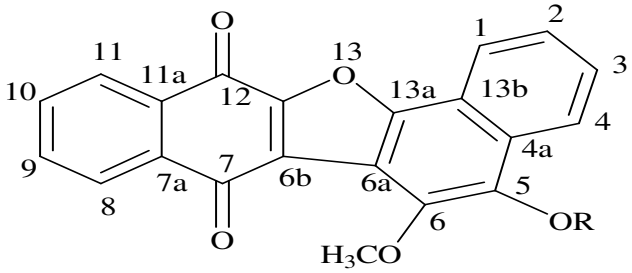
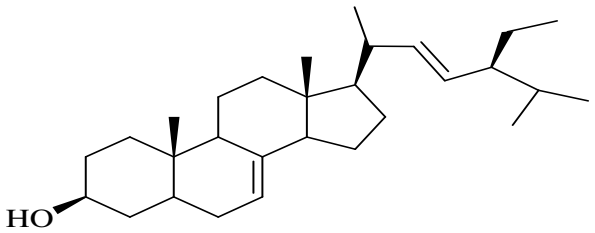


15 R= β-D-Glc
Glc = glucosyl



16 R=$COCH_3$



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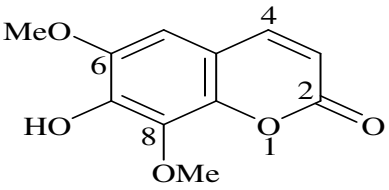

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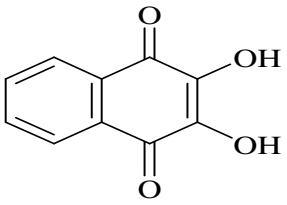

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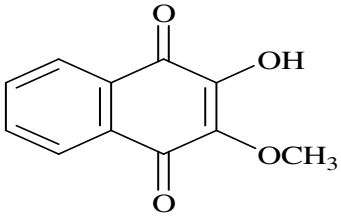

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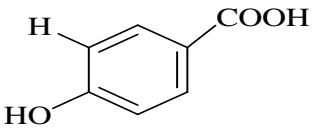

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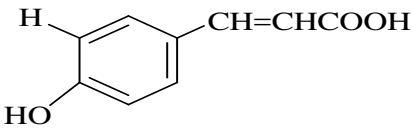

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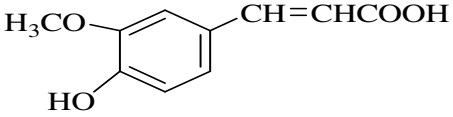

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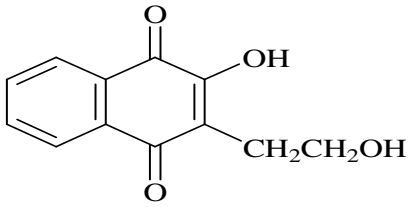

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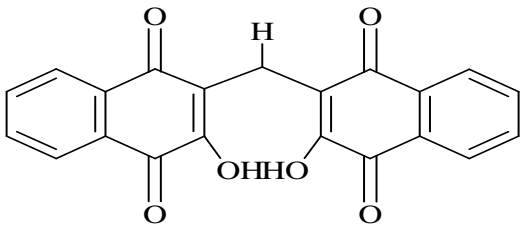

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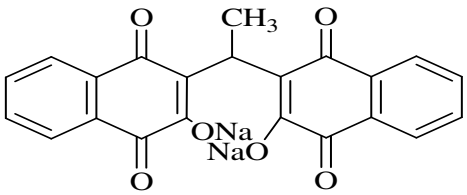

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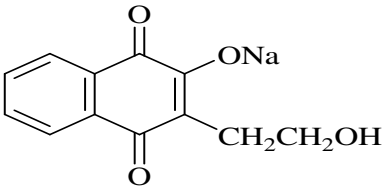

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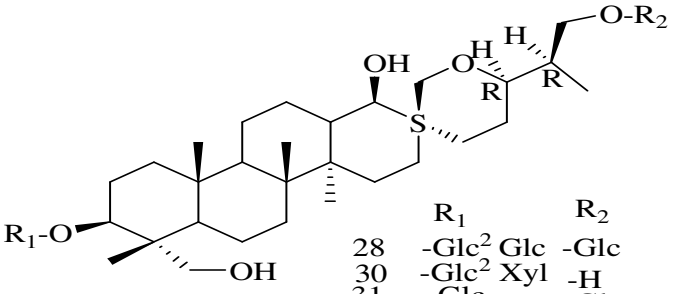
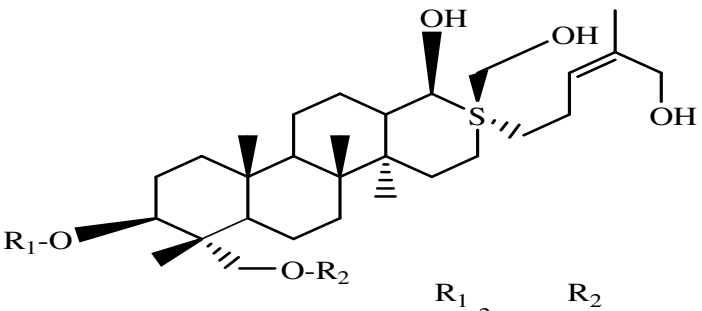


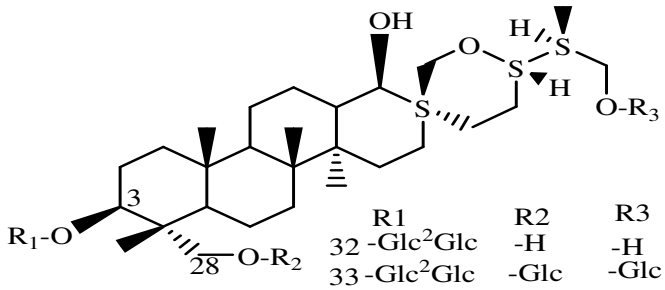
| | $R_1$ | $R_2$ |
|---|---|---|
| 28 | -$Glc^2$ Glc | -Glc |
| 30 | -$Glc^2$ Xyl | -H |
| 31 | -Glc | -Glc |

Glc = glucopyranosyl



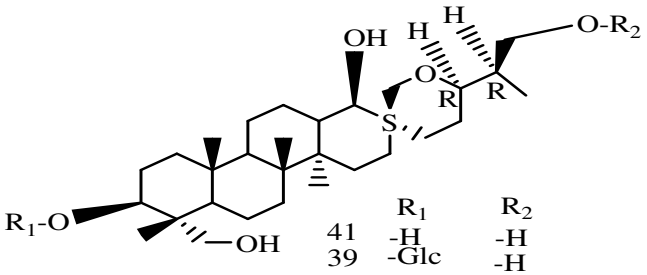
| | $R_1$ | $R_2$ |
|---|---|---|
| 29 | -$Glc^2$Xyl | -Glc |

Glc = glucopyranosyl



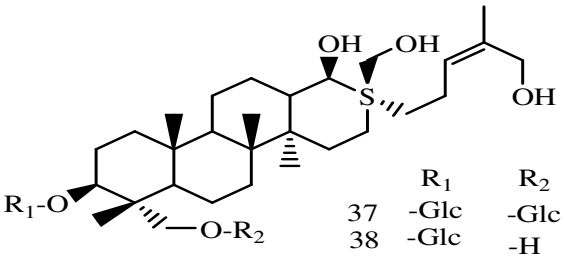
| | R1 | R2 | R3 |
|---|---|---|---|
| 32 | -Glc$^2$Glc | -H | -H |
| 33 | -Glc$^2$Glc | -Glc | -Glc |

Glc = glucopyranosyl



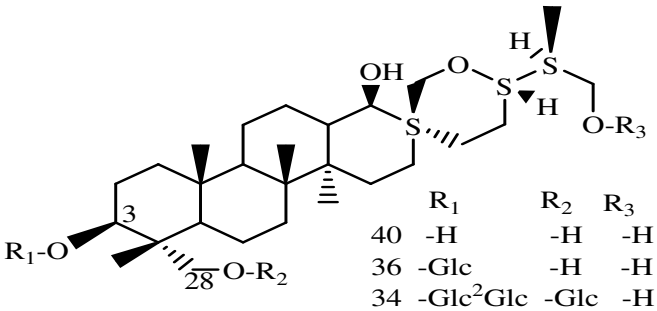
| | $R_1$ | $R_2$ |
|---|---|---|
| 41 | -H | -H |
| 39 | -Glc | -H |

Glc = glucopyranosyl



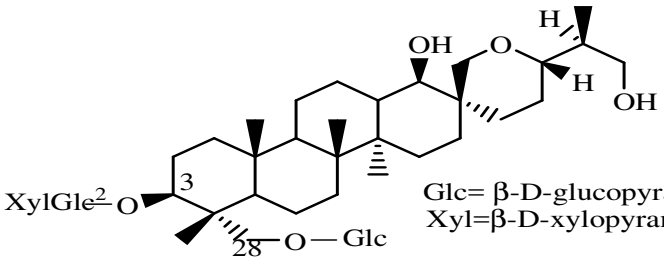
| | $R_1$ | $R_2$ |
|---|---|---|
| 37 | -Glc | -Glc |
| 38 | -Glc | -H |
| 42 | -H | -H |

Glc = glucopyranosyl



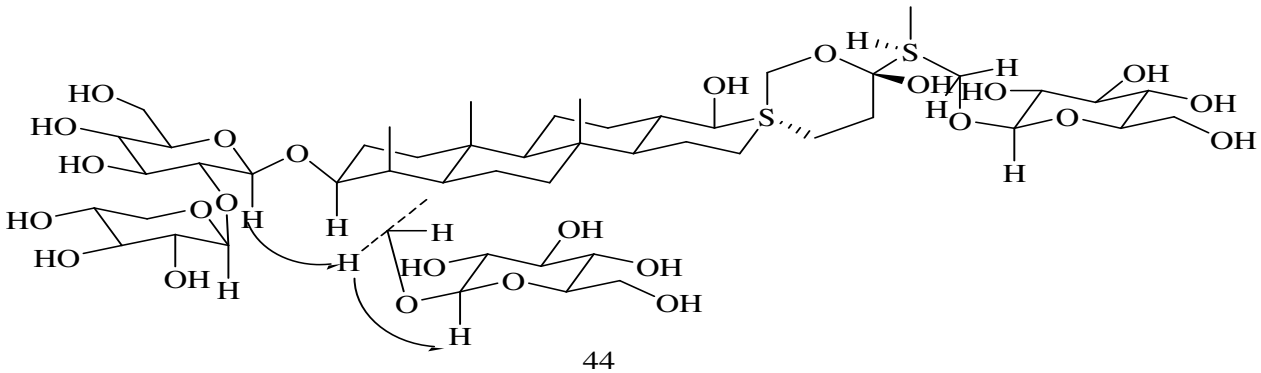
| | $R_1$ | $R_2$ | $R_3$ |
|---|---|---|---|
| 40 | -H | -H | -H |
| 36 | -Glc | -H | -H |
| 34 | -Glc$^2$Glc | -Glc | -H |
| 35 | -Glc | -GlC | -H |

Glc=β-D-glucopyranosyl



Glc= β-D-glucopyranosyl
Xyl=β-D-xylopyranosyl

43



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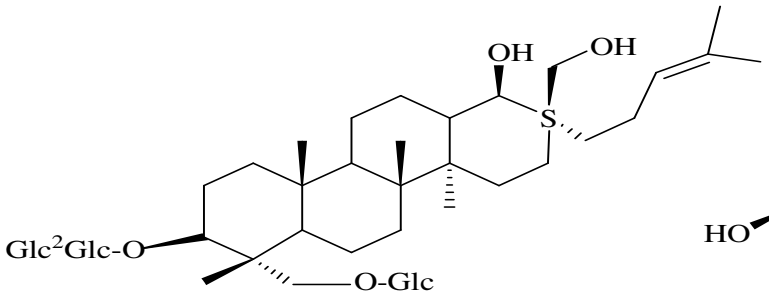
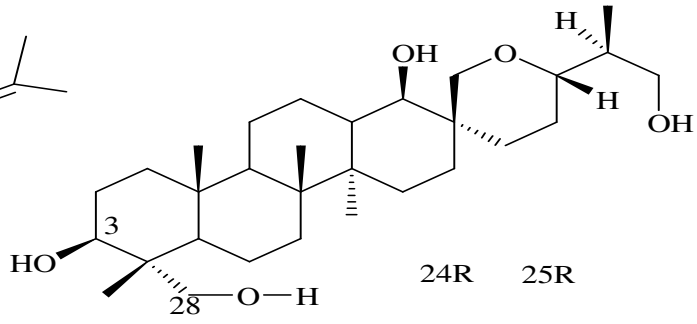


45 Glc = glucosyl

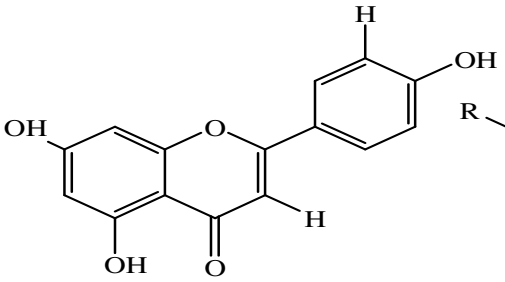


24R 25R

46

### *Impatiens textori*

Apigenin (47), apigenin 7-glucoside (48), luteolin (49) (Ueda Y et al., 2003; Ueda Y et al., 2005; Iwaoka E et al., 2010); quercetin (10), kaempferol (3), kaempferol 3-glucoside (4) (Ueda Y et al., 2003; Iwaoka E et al., 2010); chrysoeriol (50), quercetin 3-glucoside (11), kaempferol 3-rhamnosyldiglucoside (6) (Ueda Y et al., 2003); luteolin 7-glucoside (51) (Iwaoka E et al., 2010); pigment (I) malvidin 3-[6-(3-hydroxy-3-methylglutaroyl)-glucoside (52), pigment (II) malvidin 3-(6"malonyl )-glucoside (Tatsuzawa F et al., 2009).



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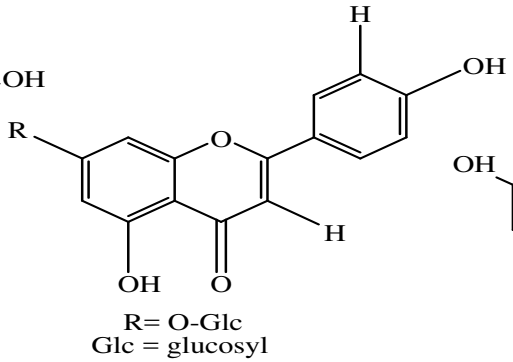
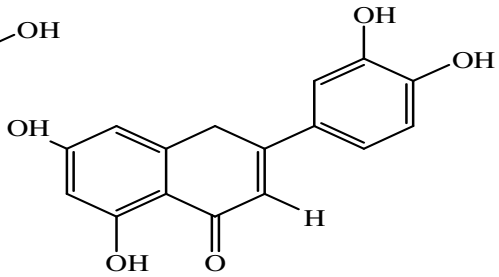


R= O-Glc
Glc = glucosyl

48



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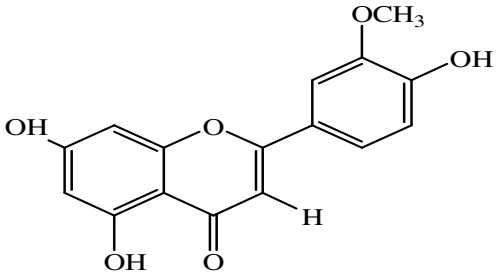

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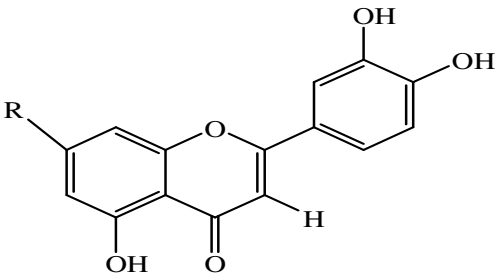
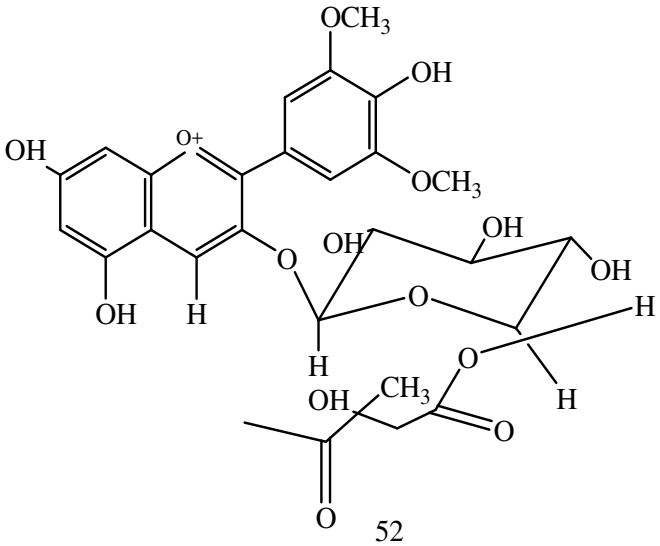


R= O-Glc
Glc = glucosyl

51



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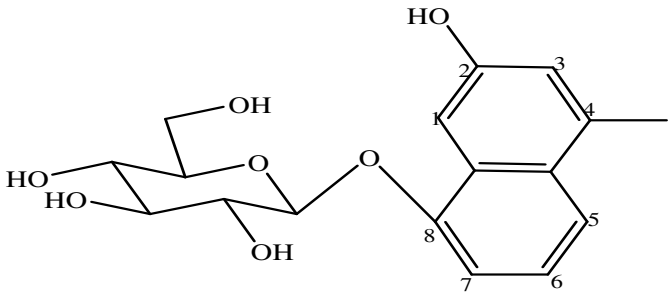


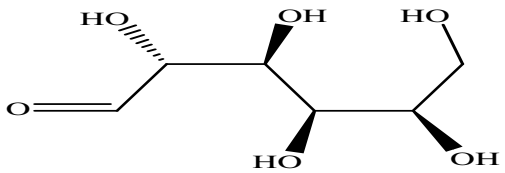
53

### *Impatiens scabrida*

Gossypetin7-O-β-D-glucopyranoside, D-glucose (54) (Yadava NR et al., 1992).

### *Impatiens glandulifera*

2-Methoxy-1,4-naphthoquinone (1) (Chapelle J et al., 1973); 1,2,4-trihydroxy napthalene-1-O-glucoside (53) (Triska J et al., 2013).

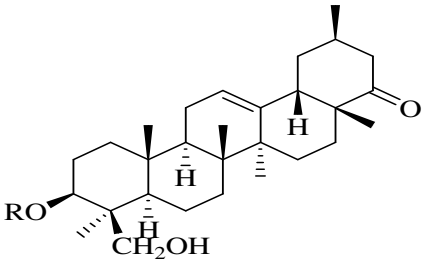


54

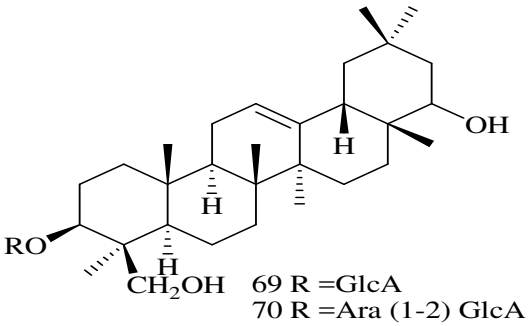
## *Impatiens siculifir*

Impatienosides (A) (55), impatienosides (B) (56), impatienosides (C) (57) , impatienosides (D) (58), impatienosides (E) (59), impatienosides (F) (60), impatienosides (G) (61), 3-O-α-L-arabinopyranosyl-(1→2)-β-D-glucurono pyranosyl-soyasapogenol (E) (62), soyasaponin Bg (63), dehydrosoyasaponin (I) (64), sandosaponin (A) (65), 22-O-β-D-glucopyranosyl-(1→3)-α-L-arabinopyranosyl-soyasapogenol (A) (66), 3-O-α-L-arabinopyranosyl-(1→2)-β-D-glucuronopyranosyl-22-O-β-D-glucopyranosyl-(1→3)-α-L-arabinopyranosyl-soya sapogenol (A) (67), soyasaponin ($A_1$) (68), soyasapogenol B monoglucuronide (69), soyasapogenin (IV) (70), soyasapogenin (I) (71), soyasapogenin (I) methyl ester (72), soyasapogenin (II) (73) (Li W et al., 2009).



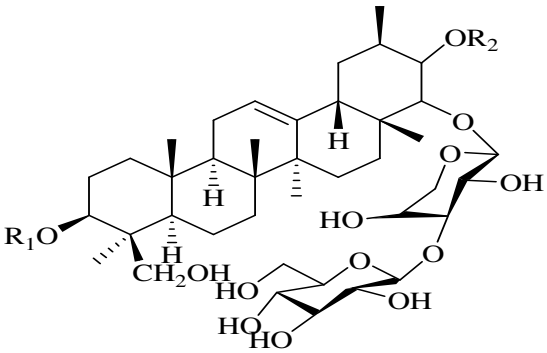
55 R= Gal(1-2)Glc A
62 R= Ara(1-2)Glc A
63 R= Rha(1-2)Ara(1-2)Glc A
64 R= Rha(1-2)Gal(1-2)Glc A
65 R= Glc(1-2)Gal(1-2)Glc A

Glc = glucosyl
Gal = galactosyl
Ara = arabinosyl
Rha = rhanosyl



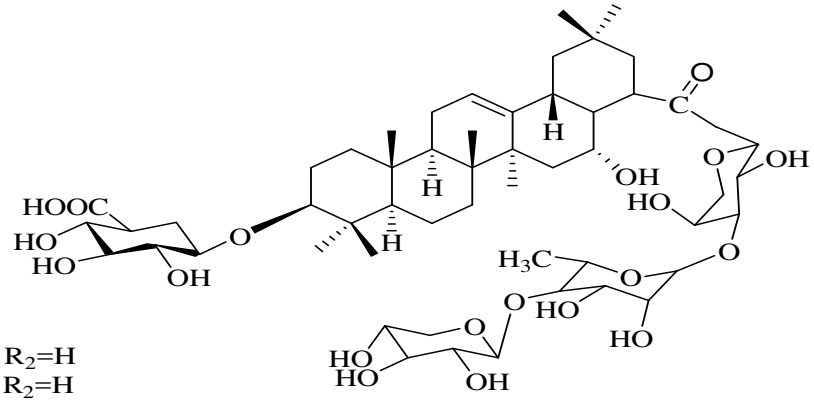
69 R =GlcA
70 R =Ara (1-2) GlcA
71 R =Rha (1-2)Gal (1-2)GlcA
72 R =Rha (1-2)Gal (1-2)GlcAMe
73 R=Rha(1-2)Ara(1-2)GlcA

Glc = glucosyl
Gal = galactosyl
Ara = arabinosyl
Rha = rhanosyl



56 $R_1$ =GlcA $R_2$=H
57 $R_1$ =Rha (1-2)Ara (1-2)GlcA $R_2$=H
58 $R_1$=Rha(1-2)Gal(1-2)GlcA $R_2$=H
59 $R_1$=Glc(1-2)Gal (1-2)GlcA $R_2$=Ac
60 $R_1$=Xyl (1-2)Gal (1-2)GlcA $R_2$=H
66 $R_1$ =$R_2$=H
67 $R_1$ =Ara (1-2)GlcA $R_2$=H
68 $R_1$= Glc (1-2)Gal(1-2)GlcA $R_2$=H

Glc = glucosyl
Gal = galactosyl
Ara = arabinosyl
Rha = rhanosyl
Xyl = xylosyl



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## *Impatiens parviflora*

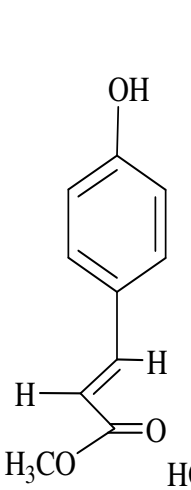
Caffeoylmalate,1,2,4-trihydroxynapthalene-1-O-glucoside, feruloylmalate, quercetin -3-O-hexoside, kaempferol-3-O-glucoside (4) (Hromadkova Z et al., 2014).

## *Impatiens bicolar*

Methyl-4-hydroxyl cinnamate (74), stigmasterol (75), stigmasterol 3-O-β-D-glucoside (76), β-sitosterol (77) (Qayum M et al., 2013); naringenin 4'-O-β-D-glucurnopyranoside (78), naringenin 4'-O-α-L- rhamnopyranoside (79), naringenin 4'-O-β-D-xylopyranoside (80), naringenin 4'-O-β-D-glucurnopyranoside, kaempferol 7-O-β-D-glucopyranoside (81), quercetin

3-O-β-D-glucopyranoside (82), kaempferol 5-O-β-D-xylopyranoside (83), kaempferol 3-O-β-D-galactopyranoside (84), kaempferol 7-O-β-D-xylopyranoside (85) (Hasan A et al., 2005).



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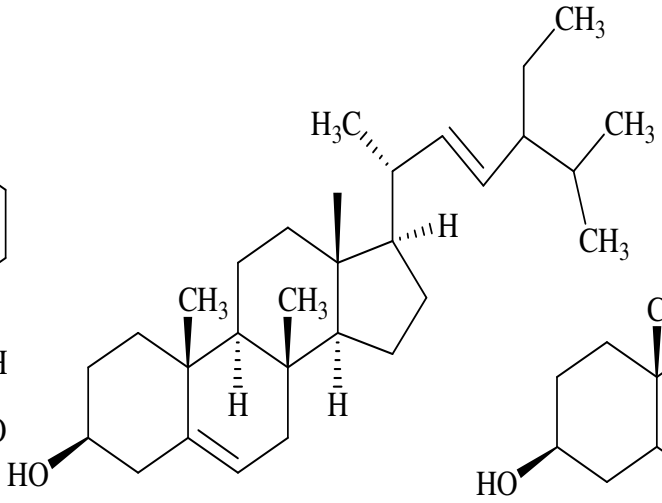

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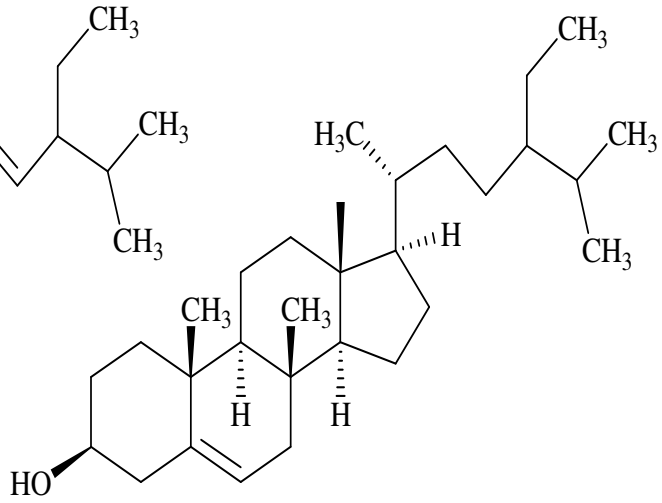

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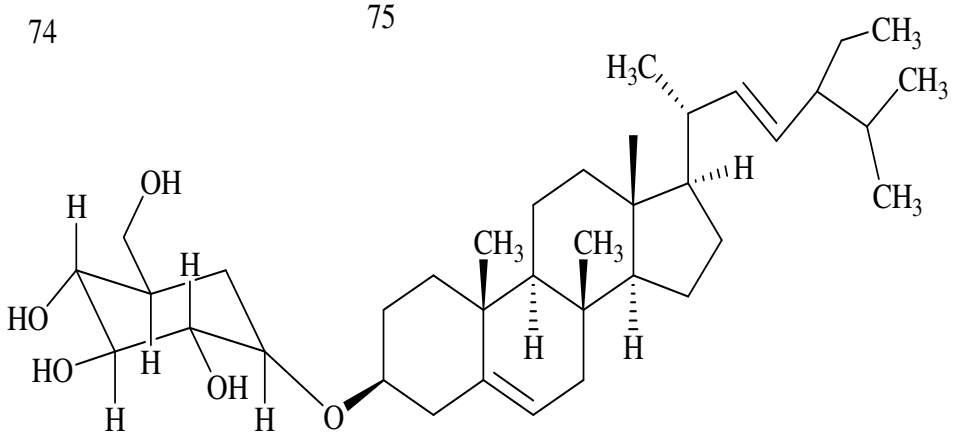

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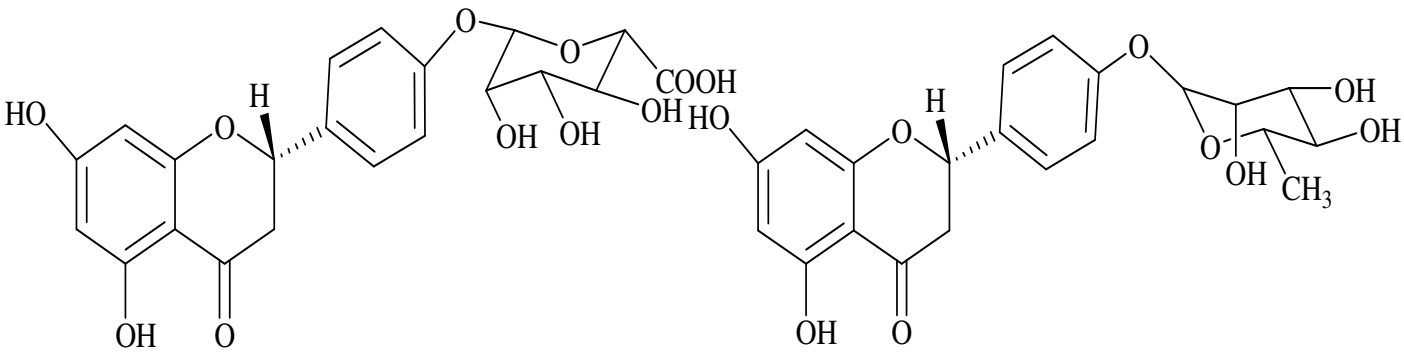

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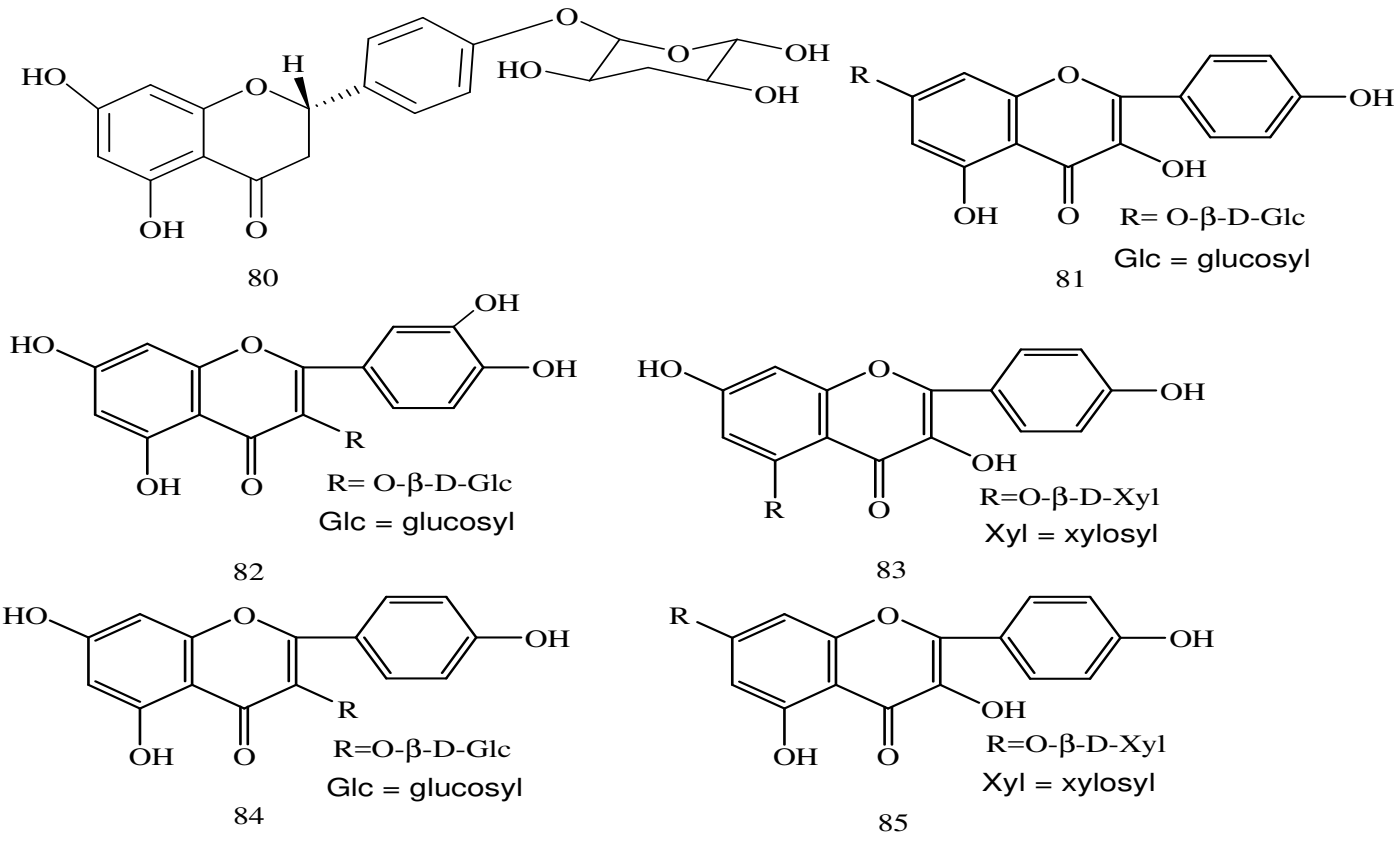
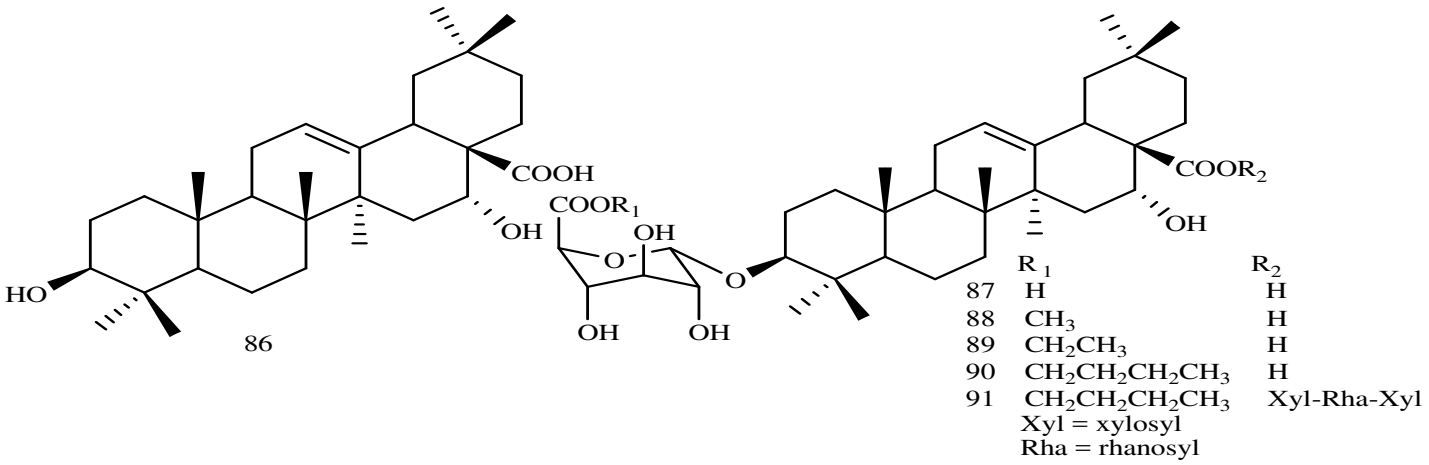



***Impatiens pritzellii***

Echinocystic acid (86), 3-O-β-D-glucuronopyranosyl echinocystic acid (87), 3-O-[(6-O-methyl)-β-D-glucuronopyranosyl] echinocystic acid (88) 3-O-[(6-O-ethyl)-β-D-glucuronopyranosyl] echinocystic acid (89), 3-O-[(6-O-n-butyl)-β-D-glucuronopyranosyl] echinocystic acid (90) and 3-O-[(6-O-n-butyl)-β-D-glucuronopyranosyl]-28-O-[β-D-xylopyranosyl–(1-4)-α-L-rhamnopyranosyl-(1-2)-β-D-xylopyranosyl echinocystic acid (91) (Zhou XN et al., 2008).




## Biological activities of genus *Impatiens*

### Immunomodulatory activity

Immunomodulatory activity of the MeOH extract and the BuOH fraction of *Impatiens pritzellii*, the collagen-induced arthritis (CIA) model in mice were used and the arthritis indexes, the spleen and thymus indexes, the levels of IgG, IL-10, INF-7 and IL-18 in serum were measured after the treatment of the MeOH extract and the BuOH fraction of *Impatiens pritzellii* in CIA mice. The progression of CIA was evaluated by macroscopic scoring. Administration of the MeOH extract at dose of 1.12 g/kg and the BuOH fraction at 0.53 g/kg suppressed the development of CIA in mice significantly. The spleen and thymus indexes were measured and the levels of IgGIL-10, INF-7 and IL-18 in the serum of CIA mice were examined after the treatment of the MeOH extract (1.12 and 1.68 g/kg body weight) and the BuOH fraction (0.40 and 0.53 g/kg body weight). Administration of the MeOH extract and the BuOH fraction of *Impatiens pritzellii* decreased the spleen and thymus indexes, down-regulated the levels of IgG, INF-7, IL-18,

and up-regulated the concentration of IL-10 in the serum of mice with CIA. From the results, it was concluded that administration of *Impatiens pritzellii* had obviously therapeutic effects on RA including immunomodulatory activity. Moreover, the BuOH fraction exerted the activity of anti-RA of *Impatiens pritzellii* (Zhou X et al., 2007).

## Antianaphylactic activity

The ethyl acetate and n-BuOH extracts of *Impatiens balsamina* showed significant anti-anaphylactic activity. The Lawson (2-hydroxy-1,4-napthoquinone) from ethyl acetate extract and nicotiflorin from the n-BuOH extract are the active principles of *Impatiens balsamina*. To investigate the anti-anaphylactic activities, the extract and isolated compounds were administered in different phases of anaphylactic response and different routes (scheme 1: antianaphylactic effect before production antibody) an extract (100 mg/kg/1mL saline) or an isolated compound (10 mg/kg/1mL saline) from *Impatiens balsamina* was administered orally. 1day before sensitization with HEL to normal mice on day 0. On day 9 each mouse was challenged with HEL after a test bleeding for heterologous PCA reation (n=10 per group). (Scheme 2: anti-anaphylactic effect after production of antibody) an extract (100mg/kg) or an isolated compound (10 mg/kg) from *Impatiens balsamina* was administered and HEL sensitized mice 1h before challenge with HEL on day 9. The time dependence of anti-anaphylactic effect of *Impatiens balsamina* after production of antibody *in vivo* assay *Impatiens balsamina* of 256 mg/kg (maximum dose possible) was administered intravenously 10, 30 and 60min before challenge (Fukumoto H et al., 1996; Ishiguro K et al., 1997).

The anti-anaphylactic activities of a 35% EtOH extract of the flowers of *Impatiens textori* were investigated by *in vivo* assay. Apigenin, apigenin 7-glucoside and luteolin are principal compounds from *Impatiens textori*, inhibited compound 48/80 (COM)-induced by blood pressure (BP) decrease, which was an immunoglobulin (Ig)E-independent anaphylaxis-like response. Compounds apigenin, apigenin 7-glucoside and luteolin all inhibited BP decrease induced by IgE-dependent anaphylaxis. Furthermore, *Impatiens textori* also inhibited the blood flow (BF) decrease induced by antigen-induced anaphylaxis in actively sensitized mice. *Impatiens textori* showed a significant inhibitory effect on scratching behavior induced by COM without a central depressant (Ueda Y et al., 2005).

## Anti-fungal activity

Seeds of *Impatiens balsamina* contain a set of related antimicrobial peptides (Ib-AMPs). Analysis of the antifungal activity of the antimicrobial peptides Ib-AMP1 and Ib-AMP4, isolated from *Impatiens balsamina* seeds was studies. It was shown moderate antifungal activity of these peptides can be drastically reduced in the presence of cations (Thevissssen K et al., 2005). The antimicrobial activity of methoxy napthoquinone was evaluated using eight fungal strains as well as all eight fungi (including multi-drug resistant strains) tested were highly sensitive to methoxy napthoquinone. The antimicrobial activity of *Impatiens balsamina* is due to the presence of methoxy napthoquinone. Methoxy naphthoquinone, or a crude *Impatiens balsamina* extract containing it, may yet prove to be a useful alternative for the treatment of systemic fungal infections, particularly those involving multi-drug resistant strains (Yang X et al., 2001).

The antifungal activities of *Impatiens bicolor* plant extracts in different solvent system by the disc diffusion assay were also studied. The antifungal activity was determined in comparison with fluconazole. EtOAc extract showed highest activity all the fungal strains which is also statistically comparable with fluconazole (Anwer N et al., 2013).

## Antibacterial activity

95% ethanol extract of the dried aerial parts of *Impatiens balsamina* subsequently identified as 2-methoxy-1,4-naphthoquinone. The antimicrobial activity of 2-methoxy-1,4-naphthoquinone was evaluated using 12 bacterial strains (five gram-positive and two gram-negative bacteria). Twelve bacterial strains were used in this study including gram-positive cocci (*Staphylococcus aureus* 236 and *S. aureus* Cowan), gram-positive rods (*Bacillus cereus, B. megaterium* and *B. subtilis* 168), gram-negative rods (*Aeromonas salmonicida* A449, *Burkholderia cepacia, Enterobacter aerogenes* 62-1, *Escherichia coli*, *Proteus mirabilis*, and *Salmonella typhimurium*), and gram-negative helical cells. Thus, all five gram-positive bacteria and two of the gram-negative ones were sensitive to 2-methoxy-1,4-naphthoquinone. The increased sensitivity of gram-positive bacteria over gram-negative bacteria. Of the five gram-negative strains that were insensitive to 2-methoxy-1,4-naphthoquinone, only two (*B. cepacia* and *S. typhimurium*) were sensitive to chloramphenicol. The remaining three (*Enterobacter aerogenes, Eschericia coli* and *P. mirabilis*) showed no inhibition to either compound at 30 g/mL. Of particular note, however, is the gram-negative bacterium *Aeromonas salmonicida* A449, which was acutely sensitive to 2-methoxy-1,4-naphthoquinone but almost unaffected by chloramphenicol. In fact, with 30 g/mL chloramphenicol, *A. salmonicida* showed no growth inhibition in the disc diffusion assay (Yang X et al., 2001). The *in vitro* antibacterial activity against antibiotic-resistant *Propionibacterium acnes* of kaempferol isolated from the *Impatiens balsamina* alone and in combination with erythromycin or clindamycin antibiotics was investigated. The antibiotic combination effect against antibiotic-resistant *Propionibacterium acnes* was studied by checkerboard test. Kaempferol and quercetin deomstrated antibacterial activitiy against *P. acnes*. Minimum inhibitory concentrations (MICs) for both compounds were ≤32 μg/mL and ≤64 μg/mL for clindamycin-sensitive and -resistant *P. acnes* (Lim YH et

al., 2007). Antibacterial activity of ethanol extract (4 mg/mL) of *Impatiens balsamina* on some bacterial strains by disc diffusion assay, results indicated that ethanol leaf extracts from *Impatiens balsamina* regardless of harvest time possess the greatest inhibitory activity, and they showed strong antimicrobial activity against bacterial strains (Kang SN et al., 2013).

The air-dried powdered plant materials of *Impatiens bicolar* extracted with different organic solvents was screened for biological activities. The antimicrobial activity was determined by the disc diffusion assay against a set of bacterial strains. The antibacterial activity was determined in comparison with ciprofloxacin. Against *E. coli*, the higher activity was shown by methanolic extract followed by EtOAc, n-hexane and $CHCl_3$. For *P. micabilus*, n-hexane extract showed better activity followed by MeOH, EtOAc and $CHCl_3$ extract. Against *S. typhimorium*, EtOAc showed highest activity which is also statistically comparable with fluconazole and mehtanol also showed good activity against *S. typhimorium* followed by n-hexane and $CHCl_3$ (Anwer N et al., 2013).

## Anti allergic Activity

The white flower of *Impatiens balsamina* extracted with ethanol and isolated the compounds (kaempferol-3-rutinoside, 2-hydroxy-1,4-naphthoquinone) were dissolved in 100 µL/saline/10gm body weight. Immunisation with HEL was performed. Male ddY mice 5 weeks of age, were sensitized intraperitoneally on day 0 with 50µg of HEL emulsified in freund's complete adjuwant on day 9 each mouse was challenged intravenously with 100µg of HEL in 30µL saline. Blood flow in the mouse tail was monitored using a laser Doppler blood flow meteron the non contact type. The blood flow of the venous microcirculation of the tail hypodermic of the unanesthesized mouse of measured every 2min it was ca 50% less than normal blood flow under anesthesia (Ishiguro K et al., 2002).

The allergy preventive activity of a 35% ethanol extract of *Impatiens textori* was demonstrated in a continuing search for allergy preventive substances from natural sources. The activity used *in vivo* assay methods for monitoring the blood flow decrease in the tail vein microcirculation of mice subjected to sensitization with hen egg white lysozyme. The principal compounds in *Impatiens textori*: apigenin and luteolin 7-glucoside showed significant allergy preventive effect (Iwaoka E et al., 2010).

## Antipruritic Activity

The antipruritic activity of compounds isolated from fresh pericarp of *Impatiens balsamina* effects of orally administered 1,4-naphthoquinone derivatives and related compounds on compound 48/80-induced scratching behavior in mice were studied. 2-Hydroxy-3-(2-hydroxyethyl)-1,4-naphthoquinone, ferulic acid, 2,2-methylenebis (3-hydroxy-1,4-naphthoquinone), and 2, 2-ethylidenebis (3-hydroxy-1, 4-naphthoquinone) all exhibited significant antipruritic activity (Ishiguro k et al., 1998; Oku K et al., 2002). A 35% ethanol extract of white petals of *Impatiens balsamina* significantly inhibited the scratching behaviour. Kaempferol, quercetin and 1,4-naphthoquinone derivatives in IB were showed antipruritic effects (Ishiguro K et al., 1997; Oku H et al., 2001).

The anti-pruritic activities of a 35% EtOH extract of the flowers of *Impatiens textori* were investigated by *in vivo* assay. Apigenin, apigenin 7-glucoside and luteolin are principal compounds from *Impatiens textori* which inhibited activity. It also significantly inhibited platelet activating factor (PAF)- and serotonin (5-HT)-induced scratching behavior and mitigated protease (PA)-induced scratching behavior. These findings showed that the flowers of *Impatiens textori* can be utilized as an anti-pruritic agent in addition to the traditional applications of this plant (Ueda Y et al., 2005).

## Antidermatitic Activity

35% Ethanolic extract from the petals of *Impatiens balsamina* and principal active compound from *Impatiens balsamina* was studied on chronic and serious pruritus and the development of dermatitis using the NC mice a model of atopic dermatitis. *Impatiens balsamina* at 100 mg/kg significantly inhibited serious scratching behavior in the NC mouse with established dermatitis when administered 1h before 24hour before the measurement. A 10 µg/kg of kaempferol 3-rutinoside and 2-hydroxy-1,4-naphthoquinone isolated from *Impatiens balsamina* also inhibited scratching behavior in the NC mouse with established dermatitis. *Impatiens balsamina* was effective for the prevention and treatment of atopic dermatitis (Oku H et al., 2001).

## Transcriptional Activity

The aerial part of *Impatiens balsamina* led to the isolation of 2-methoxy-1,4-naphthoquinone as an active compound inhibited the TCF/β-catenin (TOP) transcriptional activity ($IC_{50}$ = 2.9 µM), while it decrease the transcriptional activity of FOP (muted TCF- binding site) transfected cells at >5 µM. The Wnt signaling pathway plays main role in cell morphology, motility, proliferation and differentiation. Wnt/β-catenin signaling can also lead to the formation of tumors when aberrantly activated. Wnt signaling activates gene transcription by forming a complex between DNA-binding proteins of the TCF/LEF family and β-catenin. SuperTOPFlash, a β-catenin-responsive reporter plasmid with multiple TCF-binding sites (CCTTTGATC), was activated in cells. SuperFOP-Flash has eight mutated TCF-binding sites (CCTTTGGCC), and a selective inhibitor would prevent any enhancement of transcription in SupercFOP-Flashtransfected cells thus, the ratio of TOP/FOP-Flash reporter activity provides a measure of the selective inhibition of Wnt signaling. The result inhibition of TCF/β-catenin(TOP) transcriptional activity. Along with those for cell viability, since a decrease in cell number may

contribute to the inhibition. 1 exhibited dose dependent inhibition of TOP activity ($IC_{50}$ 2.9 l M) (Mori N et al., 2011).

## Anti-rheumatoid arthritis activity

Rheumatoid arthritis (RA) is a kind of chronic immunological and inflammatory disease. *Impatiens pritzellii* has been well known and widely used in China as an anti-rheumatoid arthritis (anti RA herbs). One of the most widely used models for studying rheumatoid arthritis is collagen induced arthritis (CIA) in mice, which shows many features with human rheumatoid arthritis. CIA in mice is an autoimmune type of arthritis, which display many characteristics in common with human RA. Four MeOH extract treated groups, the progression of arthritis, evaluated as arthritis indexes, was dramatically inhibited at the dose of 1.12 g/kg, and these had no effect at the doses of 0.56 and 2.24 gm/kg. The BuOH fraction at the dose of 0.53 gm/kg was the most effective, and the dose of 0.13 and 0.27 g/kg were inefficacious (Zhou X et al., 2007).

## Anti-Histamine activity

Ethanol extract of white petal of *Impatiens balsamina* showed the anti-histamine effects. *Impatiens balsamina* could incompletely inhibit the first stage of hypotension caused by histamine. The antianaphylactic effect of *Impatiens balsamina* was demonstrated to be different from that of diphenhydramine a typical H blocker (Fukumoto H et al., 1999).

## Testosterone 5α-Reductase Inhibitory Activity

The 35% EtOH extract of aerial parts of *Impatiens balsamina* has been investigated for activity against testosterone 5α-reductase. Activity-guided fractionation led to the identification of the bisnaphthquione derivative named as impatienol and 3-hydroxy-2-{[3-hydroxy-1,4-dioxo (2-naphthyl)] ethyl} naphthalene-1,4-dione, which exhibited significant testosterone 5α-reductase inhibitory activity (Ishiguro K et al., 2000).

## Cyclooxygenase-2 Inhibitory Activity

Compounds isolated from the corolla of *Impatiens balsamina* (two new 1,4-naphthoquinone sodium salts, sodium 3-hydroxide-2{[sodium 3-hydroxide-1,4-dioxo(2-naphthyl)]ethyl}naphthalene-1,4-dione (impatienolate) and sodium 2-hydroxide-3-(2-hydroxyethyl)naphthalene-1,4-dione (balsaminolate)), showed significant selective cyclooxygenase-2 (COX-2) inhibitory activities (Oku H et al., 2002).

## Anti Platelet Activating Activity

Several phenolic compounds which were isolated from *Impatiens balsamina* showed significant inhibitory PAF-antagonistic effects. The principal compounds from *Impatiens balsamina* kaempferol 3-glucoside, kaempferol 3-rutinoside, kaempferol 3-rhamnosyldiglucoside, quercetin, quercetin 3-glucoside and 2-hydroxy-1,4-naphthoquinone were shown to significantly inhibit PAF-induced hypotension. Those inhibitory effects were stronger than CV-3988, a PAF antagonistic agent (Oku H et al., 1999). A 35% EtOH extract of flowers of *Impatiens textori* showed an inhibitory effect on blood pressure decrease in response to platelet activating factor measured with a blood pressure monitoring system. Bioassay-guided fractionation of the 35% EtOH extract of *Impatiens textori* led to isolation of the flavones apigenin and luteolin, which significantly inhibited blood pressure decrease in response to platelet activating fector (Ueda Y et al., 2003).

## Anti Tumor Activity

Leaves of *Impatiens balsamina* have anti-tumor activity against the human hepatocellular carcinoma cell line HepG2. The ethanol extracts were separated into five fractions according to polarity. Only the chloroform fraction had a strong tumor inhibition ratio ($IC_{50}$ = 6.47 ± 0.05 mg/L), which was superior to that of curcumin ($IC_{50}$ = 13.95 ± 0.11 mg/L). However, the final active component was isolated and identified as 2-methoxy-1,4-naphthoquinone. 2-Methoxy-1,4-naphthoquinone has intensive *in vitro* anti-tumor activity against HepG2 cells (Ding ZS et al., 2008).

## O-Methyltransferase Activity

The presence of O-methyltransferase is of interest in plant tissue which produces methylated anthocyanins and hydroxycinnamic acids. It will be important to determine whether the absence of methylated anthocyanins and low levels of ferulic acid in the red genotype and the methylated anthocyanins and high levels of ferulic acid in the purple genotypes can possibly be correlated with the O-methyltransferase activities of these tissues. *Impatiens balsamina* gives O-methyltransferase activity (Masell RL et al., 1971).

## Antinociceptive Activity

The extract was evaluated for antinociceptive activity using chemical and heat Induced pain models. Methanol extract of *Impatiens balsamina* (MIB) demonstrated strong and dose-dependent antinociceptive activity in all the chemical and heat-induced mice models ($P<0.05$). MIB also showed significant central nervous system depressant effect ($P<0.05$). Antinociceptive activity of the flowers of *Impatiens balsamina* and rationalized the traditional use of the flower in the treatment of different painful condition (Imam MZ et al., 2012).

## Anti-gastric Adenocarcinoma Activity

2-Methoxy-1,4-naphthoquinone from *Impatiens balsamina* exhibited strong anti-H. pylori activity. 2-Methoxy-1,4-napthoquinone resulted in serious necrosis via superoxide anion catastrophe when the treatment doses were higher than 50μM, whereas apoptosis occurred at low treatment doses (25–50μM) through the caspase-dependent apoptosis pathway. Necrosis is the dominant mode of cell death.

2-Methoxy-1,4-napthoquinone exhibited high ability to induce gastric adenocarcinoma necrosis, showing good potential as a candidate agent for H. pylori infection related disease therapy (Wang YC et al., 2012).

## Interleukin-18 Inhibitory Activity

Echinocystic acid and 3-O-[(6-O-n-butyl)-β-D-glucuronopyranosyl]-28-O-[β-D-xylopyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→2)-β-D-xylopyranosyl] echino cystic acid obtained from the active fraction of *Impatiens pritzellii* var. *hupehensis*, which is a traditional Chinese medicine for rheumatoid arthritis, these are investigated for their effects on lipopolysaccharide(LPS)-induced interleukin (IL)-18 in human peripheral blood mononuclear cells, and showed obvious activity to inhibit the production of IL-18, especially the ester saponins with a sugar chain at C-28 (Zhou XF et al., 2008).

## Antiproliferative Activity

*Impatiens textori* was investigated for antiproliferative activities against human gastric (AGS), human cervical (HeLa), human non-small lung (A549), and human colon adenocarcinoma (HT-29) cancer cell lines. The effect of the ethyl-acetate fraction of *Impatiens textori* on cancer cells was significant, as the extract and other fractions did not exhibit similar inhibitory activity (Yang J et al., 2012).

## α- Glucosidase Inhibitory Activity

Methanol, water and ethyl acetate extracts of *Impatiens textori* were investigated for their *α*-glucosidase inhibitory activities. Primarily, α-glucosidase inhibitory activities are expressed as $IC_{50}$ values. Among these, water fraction did not show potent inhibitory activity towards α-glucosidase, Methanol extract ($IC_{50}$ values of 21.64 ± 0.32 μg/mL) had the lowest activity, and ethyl acetate fraction ($IC_{50}$ values of 8.56 ± 0.30 μg/mL) had the strongest inhibitory activity (Yang J et al., 2012).

## Antioxidant Activity

Alcoholic extract of *Impatiens bicolor* and its various fractions were screened for antioxidant potential by DPPH radical scavenging activity. The dichloromethane, ethyl acetate and n-butanol fraction caused 82%, 50% and 34% inhibition while crude extract showed minimum inhibition i.e.1.75% only. Excellent free radical scavenging property present in these fractions of *Impatiens bicolor* may be the reason for its effectiveness in its ethnopharmacological uses against different ailments (Qayum M et al., 2013).

# CONCLUSION

It is quite evident from literature that plants of the genus *Impatiens* are very potent remedies for various ailments in traditional systems of medicine worldwide. Among them, many plants are neither investigated chemically nor scientifically evaluated for their respective activities. Moreover, a majority of constituents and plant extracts from this genus have not yet been investigated for their biological activity. Therefore, an extensive research is required to find out the biological activity and mechanism action of such constituents. Furthermore, the chemically unknown species may become a source of novel drugs; therefore, a detailed chemical analysis is required to isolate bio-active constituents from them and to trace out their biological activities. Thus, it can be concluded that the genus *Impatiens* can play an important role in modern medicinal system in the near future.

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