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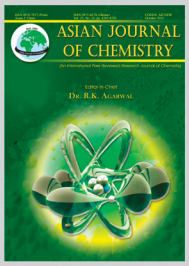

Variation of Triterpenoid Saponin Content in *Platycodon grandiflorum* (Jacq.) A.D.C.

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In this study, the accessions of the balloon flower (*Platycodon grandiflorum*) were characterized using petal colour and geographical location to determine saponin variability. Based on differences in saponin levels, the accessions with blue flowers dominated over those with white flowers for this species. Accession CB01 with blue flowers contained the highest amount of platycoside E and platycodin D3, whereas accession CB02 with the same coloured flower contained the highest amount of platyconic acid and platycodin D. Accession KW01 with white flowers contained the highest amount of Deapio-Platycoside E, platyconic acid, platycodin D2 and platycodin D. Among the accessions studied the CB01 and CB02 accessions might be considered as potential accessions in terms of saponin contents.

Key Words: Blue and white flower colour accession, Saponins, *Platycodon grandiflorum*.

INTRODUCTION

The balloon flower (*Platycodon grandiflorum*) is a member of the Campanulaceae family and is native to northeast Asia. More than 2000 years ago, this species was used as an herb in China and modern clinical tests have determined its efficacy. *Platycodi radix*, which is the root of *Platycodon grandiflorum*, is also used as a vegetable[1,2]. The root is widely used in traditional oriental medicine as an expectorant and antitussive to treat patients with cough, cold, upper respiratory tract infections, sore throat, tonsillitis and chest congestion[3]. Platycodin saponins are the primary bioactive components of *Platycodi radix*[1] and exert a wide range of effects, including antiinflammatory and antiallergic effects and inhibit tumor growth, augment immune response and stimulate apoptosis of cells of the skin[4-7]. In the last decade, there has been a renewed interest in platycodin saponins owing to their novel pharmacological potentials for treating adult diseases such as hyperlipidemia, hypertension, diabetes and obesity[8,9]. Chemical analysis of *P. radix* showed that triterpenoid saponins[2,10,11] were the main chemical components. To date, more than 30 triterpenoid saponins have been isolated from this plant[12]. The majority of research on the balloon flower has been associated with its medicinal value, particularly for different types of saponins. However, there has been limited research on the selection of potential accessions based on the different saponin contents. Considering the importance of selecting the most viable accessions of the balloon flower, this study explored the saponin content of balloon flowers with different accession numbers collected from different sources across Asia (China and Korea). Within this framework, we conducted tests to identify and quantify different saponins, including deapio-platycoside E, platycoside E, platycodin D3, platyconic acid, platycodin D2 and platycodin D, to determine the accession of the balloon flower that had the greatest medicinal utility.

EXPERIMENTAL

Extraction of saponins: Samples (*ca.* 5 g) were extracted using 200 mL of 100 % MeOH at room temperature. The extract was filtered using a filter paper (Whatman No. 42) and then evaporated (Heidoph VV2011, 40 ºC). The evaporated extract was resuspended with 5 mL of distilled water and the samples were then freeze-dried. For HPLC analysis, 0.1 g of the freeze-dried samples was resuspended in 2 mL distilled.

HPLC analysis: The saponins were analyzed using the HPLC system model NS-4000 (Futecs Co., Daejeon, Korea) with evaporation light scattering detector (ELSD). Separation was performed on an Optimapak (4.6 mm × 250 mm 5 µm, 100, RStech, Korea), with a flow rate of 0.8 mL min^{-1}. Mobile phase was used with 50 mM ammonium acetate solution,

acetonitrile, methanol; solvent A: ammonium acetate:acetonitrile:methanol at a ratio of 85:10:5 and solvent B: ammonium acetate:acetonitrile:methanol at a ratio of 55:40:5. Subsequently, an increasing amount of solvent B was added at 0-15 % (5 min), 38 % (28 min), 40 % (33 min), 43 % (53 min), 60 % (63 min), 100 % (71 min) and finally 20 µL of the sample was injected. Saponins were identified and quantified by comparing the retention times and the peak areas, respectively, with standard solution or by direct addition of standard solution into the sample (spike test). Sample aliquots were filtered through a 0.45 µm poly(tetrafluoroethylene) filter before injection. All the samples were run in triplicate. This method was performed as describe previously[3].

RESULTS AND DISCUSSION

A total of 11 accessions of the balloon flower were collected for the analysis of saponins. Of these, 8 accessions were obtained from China and the remaining 3 were obtained from Korea. The accessions were divided in 2 categories based on flower colour. Among the 11 accessions, 6 were blue flowers and 5 were white flowers. Most of the accessions with blue flowers originated in China (5 were from China and only 1 was from South Korea).

Among the accessions with white flowers, 3 were collected from China and the remaining 2 were collected from Korea (North). The codes, numbers and flower colours of all the accessions are presented in Table-1 and white and blue balloon flowers are shown in the Fig. 1.

TABLE-1
ACCESSION CODE AND NUMBER, ORIGIN AND COLOR OF THE BALLOON FLOWER

Accession code and number	Origin	Flower color
CB01	Longjing, Jilin, China	Blue
CB02	Changchun, Jilin, China	Blue
CB03	Ningan, Heilongjiang, China	Blue
CB04	Chifeng, Neimeng, China	Blue
CB05	Linyi, Shandong, China	Blue
KB01	Chunchon, Kangwon, Korea (South)	Blue
CW01	Longjing, Jilin, China	White
CW02	Yanji, Jilin, China	White
CW03	Meihekou, Jilin, China	White
KW01	Sinuiju, Pyonganbuk, Korea (Norh)	White
KW02	Najin, Hamgyongbuk, Korea (North)	White

Fig. 1. White and blue balloon flowers

The present study showed that a significant variation in the types of saponins present in different accessions of the balloon flower collected from China and Korea. The saponins identified are known to consist of important ingredients for many foods and drugs of humans. Six important saponins (*i.e.*, deapio-platycoside E, platycoside E, platycodin D3, platyconic acid, platycodin D2 and platycodin D) from 11 different accessions of the balloon flower were analyzed to determine the most viable accessions for medicinal use, by identifying accessions with the highest saponin content. The results of this clearly show that the saponin content was higher in the accessions with blue flowers than in those with white flowers (Table-2). Deapio-platycoside E is a new bisdesmosidic saponin, which was isolated from *Platycodon grandiflorum*. The deapio-platycoside E saponin content of blue balloon flower with accession number CB03 exceeded by 65, 58, 56, 21 and 20 % of that of blue balloon flowers with accession numbers CB04, CB05, KB01, CB02 and CB01, respectively. Deapio-platycoside E is a new compound that was isolated from the root of the balloon flower[12]. The accession CB01 of the blue flower contained much more platycoside E than other blue flower accessions. The content of platycoside E varied more widely across accession with blue flowers than across accession with white flowers. Among the blue flowers platycodin D3 content of the accession CB01 exceeded by 40, 36, 30, 16 and 3 % that of CB05, CB04, KB01, CB03 and CB02 accessions with blue flower, respectively. Accession CW02 with white flowers contained the highest amount of platycodin D3. Accession CB02 with the blue flower contained the highest amount of platyconic acid, which was more than 36, 33, 30, 27 and 12 % in comparison to the other blue flower accessions of CB04, CB01, KB01, CB05 and CB03, respectively. The platycodin D2 content in the accessions of the blue balloon flower was almost twice that of the accessions of the white balloon flower. The platycodin D2 content of the blue flower accession CB05 exceeded by 35, 31, 21, 18 and 11 % that of the other blue flower accessions, *i.e.*, CB03, CB04, KB01, CB01 and CB02, respectively. Platycodin D is the major saponin of *Platycodi radix* and reduces cholesterol levels in humans. The platycodin D content of the blue flower accession CB02 exceeded by 33, 28, 21, 18 and 4 % that of the other blue flower accessions, *i.e.*, CB04, KB01, CB01, CB03 and CB05 , respectively. Among the white flower accessions,

TABLE-2
SAPONIN CONTENT OF BLUE AND WHITE BALLOON FLOWERS

Flower color	Accession number	Saponin (μg/g)					
		Deapio-Platycoside E	Platycoside E	Platycodin D3	Platyconic acid	Platycodin D2	Platycodin D
Blue	CB01	73.1 ± 5.2	309.8 ± 32.6	67.2 ± 6.3	182.4 ± 20.3	96.8 ± 11.3	441.5 ± 39.5
	CB02	71.7 ± 8.1	249.8 ± 21.8	65.1 ± 5.9	272.7 ± 24.8	104.9 ± 12.5	555.5 ± 62.2
	CB03	91.3 ± 8.3	138.4 ± 11.6	56.7 ± 6.2	240.1 ± 27.1	76.7 ± 8.4	457.5 ± 50.8
	CB04	31.5 ± 2.5	115.2 ± 10.3	43.1 ± 3.6	174.2 ± 15.8	80.9 ± 6.9	371.4 ± 34.6
	CB05	38.4 ± 3.2	144.8 ± 15.2	40.2 ± 3.9	197.7 ± 21.8	117.9 ± 12.6	533.2 ± 47.3
	KB01	40.2 ± 3.7	148.4 ± 15.6	46.9 ± 4.7	190.9 ± 17.5	93.1 ± 10.4	401.6 ± 37.1
White	CW01	36.4 ± 4.4	139.2 ± 12.8	37.0 ± 3.4	140.8 ± 12.4	56.0 ± 8.2	255.8 ± 31.6
	CW02	35.7 ± 4.2	103.7 ± 9.4	44.8 ± 5.1	169.6 ± 17.8	58.2 ± 5.6	323.1 ± 36.2
	CW03	30.8 ± 2.8	110.2 ± 10.7	39.9 ± 4.3	152.2 ± 13.6	50.1 ± 4.8	258.7 ± 23.5
	KW01	41.1 ± 3.7	116.5 ± 12.5	42.4 ± 3.8	204.2 ± 18.5	68.7 ± 7.4	410.6 ± 38.4
	KW02	27.0 ± 2.3	134.8 ± 11.3	37.8 ± 3.5	140.5 ± 13.6	61.2 ± 5.7	335.1 ± 30.9

KW01 contained the highest amount of platycodin D. Chemical analysis of the saponin of the balloon flower was performed according to the reported method[13] and analysis of platycodin D was performed according to the known method[3]. This study showed a high degree of variation in platycodin D saponin content. Among the balloon flower accession several have been reported to be useful as medicinal plant species, such as *Artemisia annua*[14], *Neurolaena lobata*[15], *Valeriana officinalis*[16] and *Hypericum perforatum*[17]. The results of this study may potentially contribute towards the identification of accessions of the balloon flower with high saponin content within localized farming systems and for the regional commercialization of the balloon flower as a functional vegetable and for medicinal purposes.

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