Phytochemical and Biological Properties of *Ajuga decumbens* (Labiatae): A Review

Boran Ni¹, Xiaoxv Dong², Jing Fu², Xingbin Yin², Longfei Lin², Zhenwen Xia², Yang Zhao², Dan Xue², Chunjing Yang² and Jian Ni¹*

¹School of Basic Medical Sciences, ²School of Chinese Pharmacy, Beijing University of Chinese Medicine, Beijing, 100102, China

*For correspondence: Email: njtcm@263.net; Tel: 010-84738607

Received: 4 March 2015  Revised accepted: 23 June 2015

**Abstract**

*Ajuga decumbens* Thunb is a member of Labiatae family and widespread in China, Korea and Japan. This plant possesses diverse pharmacological activities, such as anti-inflammatory, antitumor, antibacterial, antiviral, cytotoxic, as well as insecticidal activities. Several compounds have been isolated from *A. decumbens*, which display a wide spectrum of biological and pharmacological activities. Hence, it would be useful to review current literature for available pharmacological activities of the plant as well as its active ingredients.

**Keywords:** *Ajuga decumbens* Thunb, Anti-inflammatory, Antitumor, Antibacterial, Antiviral, Cytotoxic, Insecticidal, Diterpenes, Iridoids glycosides

**INTRODUCTION**

The genus *Ajuga* is widely spread throughout the temperate regions of Europe, Asia, Australia, North America, and Africa [1,2]; this group contains many medicinal plants such as *A. decumbens* Thunb., *A. bracteosa* Wall. ex Benth, *A. forrestii* Diels, *A. nipponensis* Makino, *A. ciliata*, etc. Studies have shown that *Ajuga* spp. are widely used for the treatment of hypertension, hyperglycemia, pneumonia, acute and chronic pharyngitis [3-6]. Additionally, *Ajuga* has been used in Iranian traditional medicine for the treatment of joint pain, gout, and jaundice [7]. All plants of *A. decumbens* have been utilized as a kind of folk medicine for a long time in China and Japan owing to their antibacterial, anti-inflammatory, antitumor and antiviral activities [8-11]. Many compounds whose structures have been characterized were isolated from *A. decumbens*. Diterpenes and iridoid glycosides are the main bioactive compounds for the treatment of chronic pelvic inflammation and hysteromyoma [12,13]. It is urgent to understand the structure-activity relationships between the chemical constituents and biological activities of this plant with regard to its enormous social and economic implications. The primary objective of this review is to comprehensively report the various biological properties of *A. decumbens* as well as its main chemical constituents.

**Diterpenes**

Previous investigations of *A. decumbens* indicate that its constituents can be classified into four categories, viz, diterpenes, iridoid glycosides, flavonoids and ecdy steroids. Among them, diterpenes and iridoid glycosides are predominant. Neo-clerodane diterpenes mostly
show insecticidal [14,15], antibacterial [16,17], antimalarial [18], and anticancer activities [19]. In 1989, eight compounds, named Ajugacumbins A, B, C, D (1 - 4), Ajugamarnins A2, G1, H1 and F4 (5 - 8), were isolated from the ethanol extract of A. decumbens [20,21]. After that, two new compounds, ajugacumbins E, F (9, 10), were isolated [22]. Similarly, Chen et al also obtained a new compound (11) from A. decumbens [23]. In late 20th and early 21st century, Ajugakasins A and B (12, 13), Ajugaside A (14) were isolated from the extracts of A. decumbens [24,25]. In 2005, ajugacumin H (15) was obtained from chloroform extract of A. decumbens [26]. With the development of separation and analysis techniques, four new compounds were separated from the whole plants were: 15-epilupulin A (16), 6-O-deacetylagugamarin (17), and ajugadecumbinins A and B (18, 19) [27]. Sun et al isolated and characterized compounds 20-30 Ajugamarin A1 Chlorhydrin (20) from A. decumbens [28].

In addition the same year, they also isolated six new compounds and four well-known analogues, elucidated as (12S)-1α,19-epoxy-6β,18-diacetoxy-4α,12-dihydroxy-neoclerod-13-en-15,16-olide (21), (12S)-6α,19-diacetoxy-18 chloro-4α-hydroxy-12-tigloyloxy-neo-clerod-13-en-15,16-olide (22), (12S,2S)-6α,19-diacetoxy-18-chloro-4α-hydroxy-12-(2-methylbutanoyloxy)-neo-clerod-13-en-15,16-olide (23), 6α,19-diacetoxy-4α-hydroxy-1β-tigloyloxyne-oclrod-12-en-15-oic acid methyl ester-16-aldehyde (24), (12S)-18,19-diacetoxy-4α,6α,12-trihydroxy-1β-tigloyloxy-neo-clerod-13-en-15,16-olide (25), 4α,6α-dihydroxy-18-(4′-methoxy-4′-oxobutyrolxy)-19-tigloyloxy-neo-clerod-13-en-15,16-olide (26), Ajugaccilatin J (27), Ajuganipponin B (28), Ajugamarin A1(29), Ajugarin I (30) [29-30].

In 2014, Lv et al reported a new compound ajugacumin J (31) [31]. Besides, three clerodane diterpenoids and six abietane diterpenoids, including dihydroclerodin (32), clerodinins C (33), clerodinins D (34), ajuforrestins A, Ajuforrestins B, Ajudecuminis A–D (35 - 38), were obtained from the aerial parts of A. decumbens [32]. The structures of these compounds are described in Table 1(a), Table 1(b); Fig 1(a)-1(e).

**Iridoid glycosides**

Iridoids are a class of secondary metabolites found in a wide variety of plants primarily served as a defense against herbivores or against infection by microorganisms [33]. The iridoids glycosides were firstly found by Takeda et al obtained six iridoids glycosides from the MeOH extract of A. decumbens, elucidated as Decumbeside A-D (39 - 42), reptoside (43) and 8-Acetylharpagide (44) [34]. Similarly, Harpagide (45) was isolated from A. decumbens [25]. The structures and physical states of these compounds are described in Table 1(b); Fig 1(e), Fig 1(f).

**Flavonoids**

Flavonoids are another major group of compounds isolated from A. decumbens. Jin et al isolated luteolin (46) from the ethanol extract of A. decumbens [35]. In 2005, 7-Dihydroxy-4′-methylflavone (47) was obtained from the MeOH extract [36]. Other flavonoids, named Apigenin (48) and Acacetin (49), were isolated [28,32]. The structures and Physical states of these compounds are described in Table 1(b); Fig 1(f).

**Ecdysteroids**

Ecdysteroids are a group of chemically related polyhydroxylated steroids present in plants (phytoecdysteroids) and arthropods (zooecdysteroids). The phytoecdysteroids stimulate protein synthesis in plants and activate cell mitosis, and possibly act as plant growth regulators [37]. In 1970, Ajugalactone (50) was isolated from A. decumbens [38]. Up to 1999, eight ecdysteroids (51 - 58) were obtained from the flowering whole plant [39]. The structures of these compounds are described in Fig 1(f), Fig 1(g).

**Others compounds**

Two known compounds (59 - 60), a new phenethyl alcohol glycoside (61) were isolated from A. decumbens [25]. In 1999, two compounds (62 - 63) were obtained and structurally characterized from the flowering whole plant of A. decumbens [39].

A few years later, four compounds, (6R,7E,9R)-9-hydroxy-4,7-megastigmadien-3-one (64), (3S,5R,6S,7E)-5,6-epoxy-3-hydroxy-7-megastigmen-9-one (65), (6E,9S)-9-hydroxy-4,6-megastigmadien-3-one (66), 6-hydroxy-4,7-megastigmadiene-3,9-dione (67) were identified by comparison of their NMR, optical rotation and MS data with those reported in the literature [32,40,41]. In the same year, five other compounds (68 - 72) were obtained from the methanol extract [28]. The structures of these compounds are stated in Fig 1(g) and Fig 1(h).
Table 1: Compounds isolated from *A. decumbens* Thunb.

| No. | Name                          | Physical state        | Ref |
|-----|-------------------------------|-----------------------|-----|
| 1   | Ajugacumbins A                | Colorless crystal     | [20]|
| 2   | Ajugacumbins B                | Colorless crystal     | [20]|
| 3   | Ajugacumbins C                | Amorphous powder      | [20]|
| 4   | Ajugacumbins D                | Colorless crystals    | [20]|
| 5   | Ajugamarins A2                | Amorphous solid       | [21]|
| 6   | Ajugamarins G1                | Colorless crystal     | [21]|
| 7   | Ajugamarins H1                | Colorless needle      | [21]|
| 8   | Ajugamarins F4                | Colorless crystal     | [21]|
| 9   | Ajugacumbins E                | Colorless crystal     | [22]|
| 10  | Ajugacumbins F                | Colorless crystal     | [22]|
| 11  | Ajugacumbins G                | Colorless crystal     | [23]|
| 12  | Ajugatakasins A               | Colorless oil         | [24]|
| 13  | Ajugatakasins B               | Amorphous solid       | [24]|
| 14  | Ajugaside A                   | Colorless crystal     | [25]|
| 15  | Ajugacumbins H                | Colorless crystal     | [26]|
| 16  | 15-epilupulin A               | Colorless needle      | [27]|
| 17  | 6-O-deacetylajugamarin        | Colorless needle      | [27]|
| 18  | Ajugadecumbenins A            | Colorless needle      | [27]|
| 19  | Ajugadecumbenins B            | Amorphous powder      | [27]|
| 20  | Ajugamarin A1 chlorhydrin     | Amorphous powder      | [28]|
| 21  | (12S)-1a,19-epoxy-6a,18-diacetoxy-4a,12-dihydroxy-neo-clerod-13-en-15,16-olide | Colorless flake | [29]|
| 22  | (12S)-6a,19-diacetoxy-18-chloro-4a-hydroxy-12-tigloyoxy-neo-clerod-13-en-15,16-olide | Colorless flake | [29]|
| 23  | (12S,2'S)-6a,19-diacetoxy-18-chloro-4a-hydroxy-12-(2-methylbutanoyloxy)-neo-clerod-13-en-15,16-olide | White powder | [29]|
| 24  | 6a,19-diacetoxy-4a-hydroxy-1β-tigloyoxy-neo-clerod-12-en-15-oic acid methyl ester-16-aldehyde | Colorless oil | [30]|
| 25  | (12S)-18,19-diacetoxy-4a,6a,12-trihydroxy-1β-tigloyoxy-neo-clerod-13-en-15,16-olide | White powder | [30]|
| 26  | 4a,6a-dihydroxy-18-(4'-methoxy-4'-oxobutyryloxy)-19-tigloyoxy-neo-clerod-13-en-15,16-olide | White powder | [30]|
| 27  | Ajugaciliatin J               | White powder          | [30]|
| 28  | Ajuganipponin B               | Needle crystal        | [29]|
| 29  | Ajugamarin A1                 | Colorless crystal     | [29]|
| 30  | Ajugarin I                    | Colorless crystal     | [30]|
| 31  | Ajugacumin J                  | Colorless oil         | [31]|
| 32  | Dihydroclerodin               | Amorphous powder      | [32]|
| 33  | Clerodins C                   | Amorphous powder      | [32]|
| 34  | Clerodins D                   | Amorphous powder      | [32]|
| 35  | Ajudecumins A                 | Needle crystal        | [32]|
| 36  | Ajudecumins B                 | Amorphous solid       | [32]|
| 37  | Ajudecumins C                 | Amorphous solid       | [32]|
| 38  | Ajudecumins D                 | Orange oil            | [32]|
| 39  | Decumbeside A                 | Amorphous powder      | [34]|
| 40  | Decumbeside B                 | Amorphous powder      | [34]|
| 41  | Decumbeside C                 | Amorphous powder      | [34]|
| 42  | Decumbeside D                 | Amorphous powder      | [34]|
| 43  | Reptoside                     | Amorphous powder      | [34]|
| 44  | β-acetylharpagide             | Amorphous powder      | [34]|
| 45  | Harpagide                     | Amorphous powder      | [25]|
| 46  | Luteolin                      | Amorphous powder      | [35]|
| 47  | 5,7-dihydroxy-4‘-methylflavone| Needle crystal        | [36]|
| 48  | Apigenin                      | Amorphous powder      | [28]|
| 49  | Acacetin                      | Amorphous powder      | [32]|
Fig 1(a): Structures of compounds from *A. decumbens* Thunb.

1. $R_1=\text{OAc, } R_2=R_3=\text{H}$
2. $R_1=\text{OH, } R_2=R_3=\text{H}$
3. $R_1=R_2=R_3=\text{OAc}$
4. $R_1=\text{OAc, } R_2=\text{H, } R_3=\text{OH}$
5. $R_1=\text{Tig, } R_2=R_3=R_4=\text{Ac}$
6. $R_1=\text{Tig, } R_2=R_3=\text{Ac, } R_3=\text{MeBu}$
7. $R_1=\text{MeBu, } R_2=R_3=\text{Ac, } R_3=\text{Tig}$

Fig 1(b): Structures of compounds from *A. decumbens* Thunb. (contd)
Fig 1(c): Structures of compounds from A. decumbens Thunb. (contd)
Fig 1(d): Structures of compounds from *A. decumbens Thunb.* (contd)
Fig 1(e): Structures of compounds from *A. decumbens* Thunb. (cont'd)
Fig 1(f): Structures of compounds from *A. decumbens* Thunb. (contd)

55 $R_1=\text{OH}, R_2=\text{CH}_2\text{-CH(OH)}(\text{CH}_3)_2$
56 $R_1=\text{H}, R_2=\text{CH}_2\text{-CH(OH)}(\text{CH}_3)_2$
57 $R_1=\text{H}, R_2=\text{CH}(\text{C}_2\text{H}_5)\text{C}(\text{CH}_3\text{OH})=\text{CH}_2$
58 $R_1=\text{H}, R_2=\text{CH}(\text{CHOH-CH}_3)\text{O}(\text{CH}_3)=\text{CH}_2$

Fig 1(g): Structures of compounds from *A. decumbens* Thunb. (contd)

59 $R_1=\text{H}, R_2=\text{OMe}$
60 $R_1=\text{R}_2=\text{H}$
61 $R_1=\text{OH}, R_2=\text{OMe}$
Ni et al

Trop J Pharm Res, August 2015; 14(8): 1533

Fig 1(h): Structures of compounds from A. decumbens Thunb. (contd)

BIOLOGICAL PROPERTIES

Various extracts or purified compounds from A. decumbens exhibit diverse biological characteristics, which are anti-inflammatory, antitumor, antibacterial, antivirus, cytotoxic, as well as insecticidal activities. Herein, we describe the biological activities as well as its active extracts or compounds.

Anti-inflammatory activities

Several studies investigated that the whole plant of A. decumbens possessed the anti-inflammatory effects described in the famous pharmacy book of China, Dictionary of Chinese Materia Medica [42-43]. The inhibitory activities on LPS-induced NO production of diterpenes were evaluated, compounds (22-26, 28) showed inhibitory effects, indicating these substances
were expected to be useful as effective potential anti-inflammatory agents [29,30]. Similarly, Ajugacumin J (31) and ajugacumin D (4) exhibited the inhibitory activities of LPS-induced NO production in RAW 264.7 macrophages with an IC50 value of 46.2 and 35.9 mM, respectively [31]. The ethanol extracts of A. decumbens extracts (KE) improved the balance of bone resorption and bone formation, showing anti-inflammatory effects. The results exhibited that KE were beneficial for sufferers of bone and joint disease [44]. Total flavonoids of A. decumbens (TFA) had a therapeutic effect on chronic serum sickness glomerulonephritis (CSS-GN) rats by increasing SOD activity, lowering MDA and inhibiting lipid peroxidation [45].

**Antitumor activities**

The inhibitory effects of these compounds (14, 43-45, 59-61) on EBV activation induced by TPA were examined via a primary screening for antitumor activity, and the results showed that 8-Acetylharpagide (44). exhibited the strongest inhibitory effect on EBV activation [25]. In addition, compound 44 exhibited an anti-proliferative effect on mouse hepatic tumor using N-nitrosodiethylamine (DEN) as an initiator and phenobarbital (PB) as a promoter [46]. Takasaki et al also found that compounds 44 and 52 had potent antitumor-promoting activities on mouse skin in vivo two-stage carcinogenesis procedure. Furthermore, compound 44 also exhibited potent chemopreventive activity in a mouse pulmonary tumor model [39]. Compounds 35 - 37 exhibited moderate inhibitory activity on the proliferation of human breast cancer MCF-7 cells [32]. A. decumbens extracts showed anticancer and antimitastatic effects towards breast cancer through regulating the expression of MMPs and TIMPs [47]. Additionally, A. decumbens extracts exhibited an anti-proliferative effect on lung cancer A-549, liver cancer SMMC-7721 and Sarcoma S18 [48,49]. What is more, water extracts of A. decumbens significantly inhibited the proliferation of HepG2 cells in a dose-dependent manner [50].

**Antibacterial activities**

A. decumbens extracts exhibited significantly antibacterial effect by inhibiting the growth of S. aureus, S. epidermidis, K. pneumonia, E. coli and P. aeruginosa [51]. Besides, through the analysis of antibacterial activity in vivo and in vitro, water extracts of A. decumbens also possessed antibacterial activities against Streptococci [52].

**Antivirus activities**

Ma et al found that the whole plant of A. decumbens showed potent antiviral activities against respiratory syncytial virus (RSV) with an IC50 value of 131.6 μg/ml [53]. In addition, A. decumbens water extracts could inhibit infectious bronchitis virus (IBV) in vitro with the concentration of 750 - 1500 mg/ml [54].

**Cytotoxicity**

Myrotheciumone A isolated from A. decumbens was found to exert cytotoxicity via induction of apoptosis in cancer cell lines [55].

**Insecticidal activities**

Min et al reported that these compounds (1-4, 9-10) from the ethanol extract of A. decumbens displayed growth-inhibitory properties against insects [20,22]. Similarly, compound 11 also exhibited significant insecticidal activities [23].

The active extracts/compounds of A. decumbens and their mechanisms of action are provided in Table 2.

**Table 2:** The active extracts or compounds together with their bioactivities

| Biological property | Mechanism of action | Extract/Compound no. |
|---------------------|---------------------|----------------------|
| Anti-inflammatory effect | iNOS, Lipid peroxidation | 22, 23, 24, 25, 26, 28, 31 |
| Antitumor effect | EBV, human breast cancer, lung cancer, liver cancer, HepG2 cells | 14, 43, 44, 45, 59, 60, 61 |
| Antibacterial effect | Bacterium | Water extract |
| Antivirus effect | RSV, IBV | Water extract |
| Cytotoxicity | Tumor cell lines | Myrotheciumone A |
| Insecticidal effect | insect antifeedant | 1, 2, 3, 4, 9, 10, 11 |
CONCLUSION

The chemical composition of A. decumbens (Labiatae) includes diterpenes, iridoids glycosides, flavonoids, eddyoesters, and phenethyl alcohol glycoside. A variety of biological properties recorded for A. decumbens extracts and chemical compounds indicate that they are of medicinal value. Limited efforts have, however, been made to determine the pharmacokinetics and mechanisms of action of the individual compounds of the plant. The therapeutic potentials of the new chemical compounds from the plant needs to be explored in detail.

ACKNOWLEDGEMENT

This work is partly supported by the National Natural Science Foundation of China (no. 81173563), and Compound Chinese Pharmaceutical Innovation Team of Beijing University of Chinese Medicine (no. 2011-CXTD-13).

REFERENCES

1. Cai ZY, Yi QG, Li YY, Liang XG, Gan L, He GX. Nuclear magnetic resonance characteristics of neo-clerodane diterpene in genus Ajuga. Cent South Pharm 2014; 12: 1108-1112.
2. Israéli ZH, Lyoussi B. Ethnopharmacology of the plants of genus Ajuga. Pak J Pharma Sci 2009; 22: 425-462.
3. Liu B, Shi RB, Ge XX, Zhou Y, Zhou J. Chemical constituents and Pharmacological activities of Ajuga. World PhytoMedicine 2001; 16: 96-101.
4. Nawaz HR, Malik A, Khan PM, Ahmed S. Ajugin E and F: Two withanolides from Ajuga parvifolia. Phytochem 1999; 52: 1357-1360.
5. Akbay P, Calis I, Heimann J, Sticher O. Ionon, iridoid and phenylethanoid glycosides from Ajuga salicifolia. Z Naturforsch 2003; 58c: 177-180.
6. Hilaly JE, Israéli ZH, Lyoussi B. Acute and chronic toxicological studies of Ajuga iva in experimental animals. J Ethnophar 2004; 91: 43-50.
7. Naghibi F, Mosaddegh M, Mohammadi Motamed S, Ghorbani A. Labiatae family in folk medicine in Iran: from ethnotobony to pharmacology. Iran J Pharm Res 2005; 2: 63-79.
8. Ono Y, Fukaya Y, Imai S, Yamakuni T. Beneficial effects of Ajuga decumbens on osteoporosis and arthritis. Biol Pharm Bull 2008; 31: 1199-1204.
9. Jiangsu New Medical College. Dictionary of Chinese Materia Medica. Shanghai: People’s Publishing House; 1986; p 751.
10. Konoshima, M, Shibata, S, Shimomura, T, Azuma, T. Tokyo: Yakuyo Shokubutsu Dajiten Hirokawa Publishing Co; 1963. 111p.
11. Zhang LQ, Feng L, Jia Q, Xu JW, Wang R, Wang ZT, WuYC, Li YM. Effects of β-glucosidase hydrolyzed products of harpagide and harpagoside on cyclooxygenase-2(COX-2) in vitro. Bioo Med Chem 2011; 19: 4882-4886.
12. Wang L, Lu W, Sheng Q, Wang SJ, Zhou H, Yu LS, Wang S, Jiang HD, He LC, Zeng S. Simultaneous determination of imperatorin and its 2 metabolites in dog plasma by using liquid chromatography–tandem mass spectrometry. J Pharmaceut Biomed 2012; 70: 640-646.
13. Takasaki M, Tokuda H, Nishio H, Konoshima T. Cancer chemopreventive agents (antitumor-promoters) from Ajuga decumbens. J Nat Prod 1999; 62: 972-975.
14. Jannet HB, Harzallah-Skhiri F, Mghri Z, Simmonds MSJ and Blaney WM. Responses of Spodoptera littoralis larvae to Tunisian plant extracts and to neoclerodane diterpenoids isolated from Ajuga pseudoiva leaves. Fitoterapia 2000; 71: 105-112.
15. Bondi ML, Al-Hillo MRY, Lamara K, Ladje S, BrunoM, Plozzi F, Simmonds MSJ. Occurrence of the antifeedant 14, 15-dihydroajugapitin in the aerial parts of Ajuga iva from Algeria. Biochem Sist Ecol 2000; 2: 1023-1025.
16. Jannet HB, Chaari A, Mghri Z, Martin M, Loukaci A. Neo-clerodane diterpenoids from Ajuga pseudoiva leaves. Phytochem 1999; 52: 1541-1545.
17. Chen H, Tan RX, Liu ZL, Zhao CY, Sun J. A clerodane diterpene with antibacterial activity from Ajuga lupulina. Acta Cryst C 1997; 53: 814-816.
18. Kuria KAM, Chepkony H, Govaerts C, Roets E, Busson R, de Witte P, Zupko I, Hoornaert G, Quirynen L, Maes L, et al. The antiplasmodial activity of isolates from Ajuga remotia. J Nat Prod 2002; 65: 789-793.
19. Takasaki M, Tokuda H, Nishio H, Konoshima T. Cancer chemopreventive agents (antitumor-promoters) from Ajuga decumbens. J Nat Prod 1999; 62: 972-975.
20. Min ZD, Wang SQ, Zheng QT, Wu B, Tanaka T, Linuma M. Four new insect antifeedant neo-clerodane diterpenoids, ajugacumbins A, B, C and D, from Ajuga decumbens. Chem Pharma Bull 1989; 37: 2505-2508.
21. Shimomura H, Sashida Y, Ogawa K. neo-Clerodane diterpenes from Ajuga decumbens. Chem Pharma Bull 1989; 37: 996-998.
22. Min ZD, Mizuno M, Wang SQ, Linuma M, Tanaka T. Two new neo-clerodane diterpenes in Ajuga decumbens. Chem Pharma Bull 1990; 38: 3167-3168.
23. Chen HM, Min ZD, Linuma M, Tanaka T. Clerodane diterpenoids from Ajuga decumbens. Chem Pharma Bull 1995; 43: 2253-2255.
24. Amano T, Nishida R, Kuwahara S, Jannet HB, Harzallah-Skhiri F, Mghri Z, Martin MT, Loukaci A. The antiplasmodial activity of isolates from ethnobotany to pharmacology. Iran J Pharm Res 2005; 2: 63-79.
25. Amano T, Nishida R, Kuwahara S, Jannet HB, Harzallah-Skhiri F, Mghri Z, Martin MT, Loukaci A. The antiplasmodial activity of isolates from ethnobotany to pharmacology. Iran J Pharm Res 2005; 2: 63-79.
26. Amano T, Nishida R, Kuwahara S, Jannet HB, Harzallah-Skhiri F, Mghri Z, Martin MT, Loukaci A. The antiplasmodial activity of isolates from ethnobotany to pharmacology. Iran J Pharm Res 2005; 2: 63-79.
27. Amano T, Nishida R, Kuwahara S, Jannet HB, Harzallah-Skhiri F, Mghri Z, Martin MT, Loukaci A. The antiplasmodial activity of isolates from ethnobotany to pharmacology. Iran J Pharm Res 2005; 2: 63-79.
25. Takasaki M, Yamauchi I, Haruna M, Konoshima T. New glycosides from Ajuga decumbens. J Nat Prod 1998; 61: 1105-1109.
26. Sang JS, Huang ZH, Min ZD. A New neo-Clerodane Diterpene Isolated from Ajuga decumbens. Chin J Nat Med 2005; 3: 284-286.
27. Huang XC, Qin S, Guo YW, Krohn K. Four New Noclerodane Diterpenoids from Ajuga decumbens. Helvetica Chimica Acta 2008; 91: 628-634.
28. Sun ZP, Gui LP, Guo YQ, Xu J, Li YS. Isolation and identification of chemical constituents from the whole plants of Ajuga decumbens. J Shenyang Pharm Univ 2012; 29: 759-760.
29. Sun ZP, Li YS, Jin DQ, Guo P, Song HB, Xu J, Guo YQ, Zhang L. neo-Clerodane diterpene from Ajuga decumbens and their inhibitory activities on LPS-induced NO production. Fitoterapia 2012; 83: 1409-1414.
30. Sun ZP, Li Y, Jin DQ, Guo P, Xu J, Guo YQ, Zhang L. Structure Elucidation and Inhibitory Effects on NO Production of Clerodane Diterpenes from Ajuga decumbens. Planta Med 2012; 78: 1579-1593.
31. Lu H, Luo J, Kong L. A new neo-clerodane diterpene from Ajuga decumbens. Nat Pro Res 2014; 26: 196-200.32
32. Wang B, Wang X N, Shen T, Wang SQ, Guo DX, Lou HX. Rearranged abietane diterpenoid hydroquinones from aerial parts of Ajuga decumbens Thunb. Phytochem Letts, 2012; 5: 271-275.
33. Israill Z H, Lyossi B. Ethnopharmacology of the plants of genus Ajuga. Pak J Pharm Sci 2009; 22: 425-462.
34. Takeda Y, Tsuchida S, Fujita T. Four new iridoid glucoside p-coumaroyl esters from Ajuga decumbens. Phytochem 1987; 26: 2303-2306.
35. Jin JS, Dou SH. Study on the flavonoids of Ajuga decumbens. Anhui Med J 1994; 15: 51.
36. Guo XD, Huang ZS, Bao YD, An DK, Ma L, Gu LO. Chemical constituents of Ajuga decumbens. Chinese Tradit Herbal Drugs 2005; 36: 645-648.
37. Ramazanov NSh. Phytoecdysteroids and other biologically active compounds from plants of the genus Ajuga. Chem Nat Compd 2005; 41: 361-369.
38. Koreeda M, Nakashishi K, Goto M. Ajugalactone, an insect moulting inhibitor as tested by the Chilo dipping method. J Amer Chem Soc 1970, 92:7512-7513.
39. Takasaki M, Tokuda H, Nishino H, Konoshima T. Cancer Chemopreventive Agents (Antitumor-promoters) from Ajuga decumbens. J Nat Prod 1999; 62: 972-975.
40. D’Abrosca B, DellaGreca M, Fiorentino A, Monaco P, Oriano P, Temussi F. Structure elucidation and phytotoxicity of C13 nor-isoprenoids from Cestrum parqui. Phytochem 2004; 65: 497-505.
41. Metunu R, Ngandeu F, Tchinda AT, Ngamenni B, Kapche GDWF, Djemgou PC, Ngadjui BT, Bezabih M, Abegaz BM. Chemical constituents of Treculia acuminata and Treculia africana (Moraceae). Biochem Syst Ecol 2008; 36: 148-152.
42. Edita. Dictionary of Chinese Materia Medica. Shanghai: Shanghai Science and Technology Publishing House; 2006; p 1035.
43. Chinese Pharmacopoeia Commission. Chinese pharmacopoeia. Beijing: The Medicine Science and Technology Press of China; 2010; p 325.