Journal of Applied Pharmaceutical Science Vol. 9(01), pp 142-146, January, 2019
Available online at http://www.japsonline.com
DOI: 10.7324/JAPS.2019.90119
ISSN 2231-3354

Role of scutellarin in human cancer—A review

Eric W. C. Chan*, Carine S. S. Lim, Win Yee Lim, Zhi Juin Loong, Chen Wai Wong
Faculty of Applied Sciences, UCSI University, 56000 Cheras, Kuala Lumpur, Malaysia.

ARTICLE INFO

Received on: 07/10/2018
Accepted on: 13/11/2018
Available online: 31/01/2019

Key words:
Anti-cancer, breviscapine, flavonoid, scutellarin, structure-activity relationships.

ABSTRACT

Scutellarin is a flavone glycoside isolated from *Erigeron breviscapus*, a perennial herb of the daisy family Asteraceae. The scutellarin-rich extract of *E. breviscapus*, known as breviscapine, has been used as a traditional Chinese medicine to improve blood circulation and cerebral blood supply. There is increasing scientific evidence affirming that scutellarin possesses pharmacological properties, notably, anti-cancer properties. This review is focused on scutellarin, its chemistry, and anti-cancer properties. Scutellarin induces apoptosis and cell cycle arrest and inhibits proliferation and progression of a wide spectrum of human cancer cells. Of particular interest are the multiple molecular targets and pathways of scutellarin, structure-activity relationships of its cytotoxicity, and future research. Sources of information were from ScienceDirect, Google Scholar, and PubMed.

INTRODUCTION

The use of traditional Chinese medicine (TCM) for the prevention and treatment of cancer has generated much interest. Recent monographs have documented more than 400 species of Chinese medicinal herbs associated with anti-cancer (Cai *et al*., 2004). Major classes of phenolic compounds found in these herbs include flavonoids, phenolic acids, tannins, coumarins, lignans, quinones, stilbenes, and curcuminoids.

Among the hundreds of medicinal herbs is *Erigeron breviscapus*, which is used in folk medicine for the treatment of paralysis, rheumatism, gastritis, toothache, and fever (Gao *et al*., 2017a; Wang and Ma, 2018). About 400 species of *Erigeron* have been documented in Asia, Europe, and North America, with 39 species in China, of which 14 are endemic and six are introduced (Chen and Brouillet, 2011).

Erigeron breviscapus (Vaniot) Handel-Mazzetti or Lamp Chrysanthemum belongs to the daisy family of Asteraceae (Chen and Brouillet, 2011; Gao *et al*., 2017a). It is a perennial herb that forms clumps of a meter in height. Flowers resemble those of daisies with central bright yellow disk florets surrounded by white ray florets at the periphery (Fig. 1). Each flower is actually an inflorescence known as capitulum. A traditional Chinese herb known as Deng Zhan Hua, *E. breviscapus* is found in Guangxi, Yunnan, Sichuan, Guizho, and Xizang provinces in the southwestern part of China, at altitudes of 1,200–3,600 masl. Three varieties of *E. breviscapus* have been recognized.

From the dried herbs of *E. breviscapus*, flavonoids (apigenin, apigenin-7-*O*-glucuronide, luteolin, scutellarein, and scutellarin) and phenolic acids (caffeic acid, chlorogenic acid, cynarin, isochlorogenic acid, and neochlorogenic acid) have been identified (Tian *et al*., 2017). Other classes of compounds include coumarins, glycosides, and essential oils. Scutellarin has also been reported in *Scutellaria* species (family Lamiaceae), such as *S. baicalensis*, *S. lateriflora*, and *S. racemosa* (Cole *et al*., 2008).

This review is focused on the chemistry and anti-cancer properties of scutellarin. Of particular interest are the multiple molecular targets and pathways of the compound toward a wide spectrum of human cancer cells, structure-activity relationships of cytotoxicity, and future research. References cited were procured from databases such as ScienceDirect, Google Scholar, and PubMed.

*Corresponding Author
Eric W. C. Chan, Associate Professor, Faculty of Applied Sciences, UCSI University, 56000 Cheras, Kuala Lumpur, Malaysia.
E-mail: chanwc @ ucsiuniversity @ edu.my; erchan @ yahoo.com

Figure 1. Plant (left) and flowers (right) of *E. breviscapus*.

SCUTELLARIN

Chemistry

Scutellarin (4',5,6,7-tetrahydroxyflavone-7-*O*-glucuronide) is a flavone glycoside with a molecular formula of $C_{21}H_{18}O_{12}$ and molecular weight of 462.35 g/mol (Gao *et al*., 2017a). The flavone is the glycone of scutellarein. The molecular structure of scutellarin comprises aromatic rings A and C that are fused together and attached to a phenyl ring B at position 2 of the ring C (Fig. 2). The molecule has an –OH group attached to C5, C6, and C4', a glucuronide (–OGlu) moiety at C7, a carbonyl group at C4, and a C2–C3 double bond. Compounds with similar molecular structures as scutellarin are scutellarein with –OH group at C7, hispidulin with $–OCH_3$ moiety at C6, and apigenin with –H group at C6 (Plochmann *et al*., 2007).

Besides scutellarin, other flavonoids isolated from *E. breviscapus* are apigenin, apigenin 7-*O*-glucuronide, baicalin, quercetin, quercetin-3-*O*-glucuronide, and scutellarein (Qu *et al*., 2001). Breviscapine is a crude extract of *E. breviscapus* which is used as TCM to improve blood circulation and cerebral blood supply (Gao *et al*., 2017a). The extract contains scutellarin (>85%) and apigenin-7-*O*-glucuronide as major components. Scutellarin has also been reported in other *Scutellaria* species such as *S. altissima* (Gao *et al*., 2017b), *S. barbata* (Zhang *et al*., 2003), *S. multiradiatus* (Luo *et al*., 2008), *S. acer* (Zhang *et al*., 2009b), and in the roots of *S. baicalensis*, another TCM plant with anti-cancer properties (Horvath *et al*., 2005).

Anti-cancer properties

There are two newly published reviews on the pharmacology of scutellarin by Wang and Ma (2018) and by Chledzik *et al*. (2018) that included its anti-cancer properties. Scientific evidence revealed that scutellarin possesses anti-cancer activities against a wide spectrum of cancer cells, including liver,

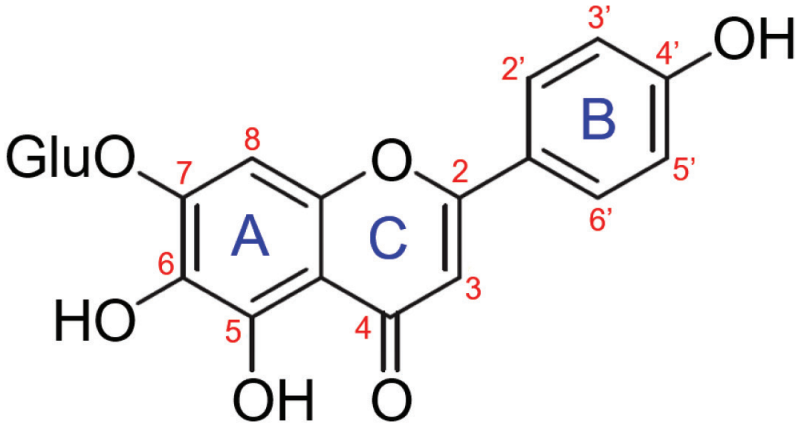

Figure 2. Molecular structure of scutellarin.

prostate, lung, breast, colon, tongue, and renal cancers. Scutellarin induces apoptosis and cell cycle arrest and inhibits proliferation and progression of cancer cells *via* multiple molecular targets and pathways (Wang and Ma, 2018). Some molecular mechanisms of scutellarin-induced growth inhibition against different cancer cell lines are listed in Table 1.

Scutellarin induced apoptosis of liver cancer cells by down-regulating Bcl-2, Bax, and caspase-3, promising to be a useful anti-cancer drug candidate against liver cancer (Wu *et al*., 2010). Similarly, scutellarin reduced reactive oxygen species production and induced apoptosis of liver cancer cells by inhibiting the signal transducer and activator of transcription (STAT) 3 pathway, and transcriptional targets of Bcl-XL and Mcl-1 (Xu and Zhang, 2013). These findings were reaffirmed by a recent study that scutellarin suppressed migration and invasion of liver cancer cells by inhibiting the activities of STAT3, Girdin, and AKT (Ke *et al*., 2017).

Against prostate cancer cells, scutellarin suppressed cell proliferation by inducing apoptosis and promoting G2/M cell cycle arrest (Gao *et al*., 2017b), and by damaging DNA and by MCM protein-7 modulation (Guan *et al*., 2017). Against lung cancer cells, scutellarin inhibited cell growth and increased apoptosis by enhancing microRNA-7 (Zeng and Cai, 2017). Concurrently, another study reported that scutellarin increased apoptosis and autophagy of lung cancer cells *via* ERK/p53 and c-met/AKT signaling pathways (Sun *et al*., 2018).

Against breast cancer cells, scutellarin inhibited cell proliferation and invasion by up-regulating the Hippo/YAP signaling pathway (Hou *et al*., 2017). Scutellarin promoted apoptosis and metastasis of colon cancer cells through activation of caspase-6 (Chan *et al*., 2009) and through inhibition of ephrinb2 signaling (Zhu *et al*., 2017). Against tongue cancer cells, scutellarin inhibited the migration of cells by regulating the production of αvβ6 integrin and E-cadherin (Li *et al*., 2010) and suppressed proliferation and induced apoptosis of cells by inhibiting MMP-2 and -9 expression (Li *et al*., 2013). In addition, scutellarin suppressed proliferation and induced apoptosis of cervical cancer cells by inhibiting the activity of pyruvate kinase M2 (You *et al*., 2017). Against renal cancer cells, scutellarin inhibited cell proliferation and migration *via* up-regulation of phosphatase and tensin homolog, and inhibition of P13K/AKT/mTOR signaling (Deng *et al*., 2018). Finally, scutellarin has been reported to induce apoptosis of B-lymphoma cells *via* activation of caspases (Feng *et al*., 2012).

SAR and cytotoxicity

A study on structure-activity relationships (SAR) conducted on cytotoxicity of 25 flavonoids against Jurkat E6-1 human leukemia cells showed that the cytotoxicity (EC_{50}) of scutellarin (44 μM) was 11.4 times stronger than that of scutellarein (502 μM) (Plochmann *et al*., 2007). Scutellarin ranked second, while scutellarein ranked eighteenth. It is evident that glucuronidation at C7 of scutellarin (Fig. 2) significantly increased its cytotoxicity. Scutellarin with triple hydroxylation at C5, C6, and C4', a C2–C3 double bond, and a C4 carbonyl group was more than 50 times more cytotoxic than taxifolin, without these structural components but an –OH group at C3 (Plochmann *et al*., 2007).

MCF-7 breast cancer cells cultured with different concentrations of scutellarin *in vitro* were analyzed for anti-proliferation and apoptosis of cells (Hou *et al*., 2017). Results showed that the inhibition rates of proliferation were 40%, 60%, and 70% for 24, 48, and 72 hours, respectively. Apoptotic cells ranged from 12.4% to 24.0% in 40–120 μM scutellarin groups, compared with 7.8% in the control group.

Results of another recent study showed that the cytotoxicity of scutellarin had IC_{50} values of 77, 73, and 56 μM against HCT-116, PC-3, and HepG-2 cancer cells, respectively

Table 1. Molecular mechanisms of scutellarin-induced growth inhibition against different cancer cell lines.

Cancer cell line	Molecular mechanism of scutellarin	Reference
Colorectal HCT116	Promoted apoptosis and metastasis of cancer cells through activation of caspase-6.	(Chan *et al*., 2009)
Tongue HSC-4 & SAS	Inhibited cell migration by regulating the production of αvβ6 integrin and E-cadherin.	(Li *et al*., 2010)
Hepatocellular HepG2	Induced apoptosis of cancer cells by down-regulating Bcl-2, Bax, and caspase-3.	(Wu *et al*., 2010)
B-lymphoma Namalwa	Promoted cell apoptosis, partially associated with the activation of caspases.	(Feng *et al*., 2012)
Tongue SAS	Suppressed proliferation and induced apoptosis of cancer cells by inhibiting the expression of MMP-2 and -9 expression, and αvβ6 integrin.	(Li *et al*., 2013)
Hepatocellular HepG2	Reduced ROS production and induced apoptosis of cancer cells by inhibiting the STAT3 pathway, and transcriptional targets of Bcl-XL and Mcl-1.	(Xu and Zhang, 2013)
Prostate PC3	Suppressed cell proliferation by inducing apoptosis and promoting G2/M cell cycle arrest.	(Gao *et al*., 2017b)
Breast MCF-7	Inhibited cell proliferation and invasion by up-regulating the Hippo/YAP signaling pathway.	(Hou *et al*., 2017)
Prostate PC3 and LNCap	Suppressed cell proliferation by damaging DNA and by MCM-7 modulation.	(Guan *et al*., 2017)
Hepatocellular HepG2 and SK-Hep1	Suppressed migration and invasion of cancer cells by inhibiting the activities of STAT3, Girdin, and AKT.	(Ke *et al*., 2017)
Cervical HeLa	Suppressed proliferation and induced apoptosis of cancer cells by inhibiting the activity of pyruvate kinase M2.	(You *et al*., 2017)
Lung A549 and NCL-H460	Inhibited cell growth and increased apoptosis by enhancing microRNA-7.	(Zeng and Cai, 2017)
Colorectal HCT116	Promoted apoptosis and metastasis of colon cancer cells through inhibition of ephrinb2 signaling.	(Zhu *et al*., 2017)
Renal ACHN and 786-O	Inhibited cell proliferation and migration *via* up-regulation of PTEN and inhibition of P13K/AKT/mTOR signaling.	(Deng *et al*., 2018)
Lung A549/DDP	Increased apoptosis and autophagy of lung cancer cells *via* ERK/p53 and c-met/AKT signaling pathways.	(Sun *et al*., 2018)

DNA = deoxyribonucleic acid; ERK = extracellular signal-regulated kinase; Girdin = girders of actin; MCM = minichromosome maintenance; MMP = matrix metalloproteinase; mTOR = mammalian target of rapamycin; PI3K = phosphoinositide 3-kinase; PTEN = phosphatase and tensin; RNA = ribonucleic acid; ROS = reactive oxygen species; STAT = signal transducer and activator of transcription; YAP = YES-associated protein; Hippo = hpo, a Drosophila kinase gene with mutants exhibiting uncontrolled tissue growth having hippopotamus phenotype.

(Han *et al*., 2017). Cytotoxicity was not observed against MCF-7 and L-O2 cancer cells. In the experiment, most of the derivatives of scutellarin synthesized with benzyl groups displayed significantly stronger cytotoxicity, including MCF-7 and L-O2 cancer cells.

Other properties

Besides anti-anticancer activities, the other pharmacological properties of scutellarin include antioxidant (Guo *et al*., 2011), neuroprotection (Guo *et al*., 2011; Wang *et al*., 2011), cardioprotection (Gao *et al*., 2017a), anti-inflammation (Wang *et al*., 2011), anti-diabetic (Long *et al*., 2015), anti-obesity (Lu *et al*., 2013), and anti-HIV (Zhang *et al*., 2005). Scutellarin also provides protection against disorders such as myocardial infarction (Huang *et al*., 2018), neuroinflammation (You *et al*., 2018; Yuan *et al*., 2016), hypertension (Chen *et al*., 2013), hypercholesterolemia (Li *et al*., 2009), cardiotoxicity (Sun *et al*., 2017), and cerebral ischemia (Lin *et al*., 2007; Zhang *et al*., 2009a).

CONCLUSION

Scutellarin possesses potent anti-cancer properties with great therapeutic potentials. However, some disadvantages limit its application due to low stability and poor oral bioavailability. Derivatives synthesized from a chemical modification of scutellarin can be developed into anti-tumor agents with high efficiency and low toxicity. SAR studies would be useful in the analysis of derivatives with enhanced cytotoxicity. Likewise, the use of scutellarin in combination with other drugs may yield better results. Future directions can also focus on human population studies and on clinical trials to evaluate the safety and efficacy of scutellarin in the prevention and treatment of cancer.

ACKNOWLEDGMENTS

We would like to acknowledge UCSI University (Proj-In-FAS-049; Proj-In-FAS-052) and the Ministry of Higher Education, Malaysia (FRGS/2/2014/SG01/UCSI/02/2) for supporting our research group.

REFERENCES

Cai YZ, Sun M, Xing J, Luo Q, Corke, H. Structure-radical scavenging activity relationships of phenolic compounds from traditional Chinese medicinal plants. Life Sci, 2005; 74:2157−84.

Chan JY, Tan BKH, Lee SC. Scutellarin sensitizes drug-evoked colon cancer cell apoptosis through enhanced caspase-6 activation. Anticancer Res, 2009; 29:3043−8.

Chen X, Shi X, Zhang X, Lei H, Long S, Su H, Pei Z, Huang R. Scutellarin attenuates hypertension-induced expression of brain toll-like receptor 4/nuclear factor kappa B. Mediators Inflamm, 2013; Article ID 432623, 9 p.

Chen Y, Brouillet L. *Erigeron* L. Flora China, 2011; 20–21:635−8.

Chledzik S, Strawa J, Matuszek K, Nazaruk J. Pharmacological effects of scutellarin, an active component of genus *Scutellaria* and *Erigeron*: a systematic review. Am J Chin Med, 2018; 46:319−37.

Cole IB, Cao J, Alan AR, Saxena PK, Murch SJ. Comparisons of *Scutellaria baicalensis*, *Scutellaria lateriflora* and *Scutellaria racemosa*: genome size, antioxidant potential and phytochemistry. Planta Med, 2008; 74:1−8.

Deng W, Han W, Fan T, Wang X, Cheng Z, Wan B, Chen J. Scutellarin inhibits human renal cancer cell proliferation and migration *via* up-regulation of PTEN. Biomed Pharmacother, 2018; 107:1505−13.

Feng Y, Zhang S, Tu J, Cao Z, Pan Y, Shang B, Liu R, Bao M, Guo P, Zhou Q. Novel function of scutellarin in inhibiting cell proliferation and inducing cell apoptosis of human Burkitt lymphoma Namalwa cells. Leuk Lymphoma, 2012; 53:2456−64.

Gao J, Chen G, He H, Liu C, Xiong X, Li J, Wang J. Therapeutic effects of breviscapine in cardiovascular diseases: a review. Front Pharmacol, 2017a; 8:289.

Gao C, Zhou Y, Jiang Z, Zhao Y, Zhang D, Cong X, Cao R, Li H, Tian W. Cytotoxic and chemo-sensitization effects of scutellarin from traditional Chinese herb *Scutellaria altissima* L. in human prostate cancer cells. Oncol Rep, 2017b; 38:1491−9.

Guan YB, Yang DR, Nong SJ, Ni J, Hu CH, Li J, Zhu J, Shan YX. Breviscapine (BVP) inhibits prostate cancer progression through damaging DNA by mini-chromosome maintenance protein-7 (MCM-7) modulation. Biomed Pharmacother, 2017; 93:103−16.

Guo H, Hu LM, Wang SX, Wang YL, Shi F, Li H, Liu Y, Kang LY, Gao XM. Neuroprotective effects of scutellarin against hypoxic-ischemic-induced cerebral injury *via* augmentation of antioxidant defense capacity. Chin J Physiol, 2011; 54:399−405.

Han T, Li J, Xue J, Li H, Xu F, Cheng K, Li D, Li Z, Gao M, Hua H. Scutellarin derivatives as apoptosis inducers: design, synthesis and biological evaluation. Eur J Med Chem, 2017; 135:270−81.

Horvath CR, Martos PA, Saxena PK. Identification and quantification of eight flavones in root and shoot tissues of the medicinal plant Huang-Qin (*Scutellaria baicalensis* Georgi) using high-performance liquid chromatography with diode array and mass spectrometric detection. J Chromatogr A, 2005; 1062:199−207.

Hou L, Chen L, Fang L. Scutellarin inhibits proliferation, invasion, and tumorigenicity in human breast cancer cells by regulating Hippo-YAP signaling pathway. Med Sci Monit, 2017; 23:5130−6.

Huang H, Geng Q, Yao H, Shen Z, Wu Z, Miao X, Shi P. Protective effect of scutellarin on myocardial infarction induced by isoprenaline in rats. Iranian J Basic Med Sci, 2018; 21:267−76.

Ke Y, Bao T, Wu X, Tang H, Wang Y, Ge J, Fu B, Meng X, Chen L, Zhang C, Tan Y. Scutellarin suppresses migration and invasion of human hepatocellular carcinoma by inhibiting the STAT3/Girdin/Akt activity. Biochem Biophy Res Commun, 2017; 483:509−15.

Li H, Huang D, Gao Z, Lv Y, Zhang L, Cui H, Zheng J. Scutellarin inhibits cell migration by regulating production of αvβ6 integrin and E-cadherin in human tongue cancer cells. Oncol Rep, 2010; 24:1153−60.

Li H, Huang D, Gao Z, Chen Y, Zhang L, Zheng J. Scutellarin inhibits the growth and invasion of human tongue squamous carcinoma through the inhibition of matrix metalloproteinase-2 and -9 and alphavbeta6 integrin. Int J Oncol, 2013; 42:1674−81.

Li Q, Wu J, Guo D, Cheng H, Chen S, Chan SW. Suppression of diet-induced hyper-cholesterolemia by scutellarin in rats. Planta Med, 2009; 75:1203−8.

Lin LL, Liu AJ, Liu JG, Yu XH, Qin LP, Su DF. Protective effects of scutellarin and breviscapine on brain and heart ischemia in rats. J Cardiovasc Pharmacol, 2007; 50:327−32.

Long L, Wang J, Lu X, Xu Y, Zheng S, Luo C, Li Y. Protective effects of scutellarin on type II diabetes mellitus-induced testicular damages related to reactive oxygen species/Bcl-2/Bax and reactive oxygen species/microcirculation/staving pathway in diabetic rat. J Diabetes Res, 2015; Article ID 252530:11.

Lu K, Han M, Ting HL, Liu Z, Zhang D. Scutellarin from *Scutellaria baicalensis* suppresses adipogenesis by up-regulating PPARα in 3T3-L1 cells. J Nat Prod, 2013; 76:672−8.

Luo P, Tan ZH, Zhang ZF, Zhang H, Liu XF, Mo ZJ. Scutellarin isolated from *Erigeron multiradiatus* inhibits high glucose-mediated vascular inflammation. J Pharm Soc Jpn, 2008; 128:1293−9.

Plochmann K, Korte G, Koutsilieri E, Richling E, Riederer P, Rethwilm A, Schreier P, Scheller C. Structure-activity relationships of flavonoid-induced cytotoxicity on human leukemia cells. Arch Biochem Biophy, 2007; 460:1−9.

Qu J, Wang Y, Luo G, Wu Z. Identification and determination of glucuronides and their aglycones in *Erigeron breviscapus* by liquid chromatography-tandem mass spectrometry. J Chromatogr A, 2001; 928:155−162.

Sun CY, Zhu Y, Li XF, Wang XQ, Tang LP, Su ZQ, Li CY, Zheng GJ, Feng B. Scutellarin increases cisplatin-induced apoptosis and autophagy to overcome cisplatin resistance in non-small cell lung cancer via ERK/p53 and c-met/AKT signaling pathways. Front Pharmacol, 2018; 9:92.

Sun XP, Wan LL, Yang QJ, Huo Y, Han YL, Guo C. Scutellarin protects against doxorubicin-induced acute cardiotoxicity and regulates its accumulation in the heart. Arch Pharm Res, 2017; 40:875−83.

Tian Y, Li Q, Zhou X, Pang Q, Xu Y. A UHPLC-MS/MS method for simultaneous determination of twelve constituents from *Erigeron breviscapus* extract in rat plasma: application to a pharmacokinetic study. J Chromatogr B, 2017; 1046:1−12.

Wang L, Ma Q. Clinical benefits and pharmacology of scutellarin: a comprehensive review. Pharmacol Ther, 2018; 190:105−27.

Wang S, Wang H, Guo H, Kang L, Gao X, Hu L. Neuroprotection of scutellarin is mediated by inhibition of microglial inflammatory activation. Neuroscience, 2011; 185:150−60.

Wu Y, Fan Q, Lu N, Tao L, Gao Y, Qi Q, Guo Q. Breviscapine-induced apoptosis of human hepatocellular carcinoma cell line HepG2 was involved in its anti-tumour activity. Phytother Res, 2010; 24:1188−94.

Xu H, Zhang S. Scutellarin-induced apoptosis in HepG2 hepatocellular carcinoma cells *via* a STAT3 pathway. Phytother Res, 2013; 27:1524−8.

You L, Zhu H, Wang C, Wang F, Li Y, Li Y, Wang Y, He B. Scutellarin inhibits HeLa cell growth and glycolysis by inhibiting the activity of pyruvate kinase M2. Bioorg Med Chem Lett, 2017; 27:5404−8.

You P, Fu S, Yu K, Xia Y, Wu H, Yang Y, Ma C, Liu D, Chen X, Wang J, Ye X. Scutellarin suppresses neuro-inflammation *via* the inhibition of the AKT/NF-κB and p38/JNK pathway in LPS-induced BV-2 microglial cells. Naunyn-Schmiedeberg's Arch Pharmacol, 2018; 391:743−51.

Yuan Y, Fang M, Wu CY, Ling EA. Scutellarin as a potential therapeutic agent for microglia-mediated neuro-inflammation in cerebral ischemia. Neuromol Med, 2016; 18:264−73.

Zeng J, Cai S. Breviscapine suppresses the growth of non-small cell lung cancer by enhancing microRNA-7 expression. J Biosci, 2017; 42:121−9.

Zhang GH, Wang Q, Chen JJ, Zhang XM, Tam SC, Zheng YT. The anti-HIV-1 effect of scutellarin. Biochem Biophy Res Commun, 2005; 334:812−6.

Zhang HF, Hu XM, Wang LX, Xu SQ, Zeng FD. Protective effects of scutellarin against cerebral ischemia in rats: evidence for inhibition of the apoptosis-inducing factor pathway. Planta Med, 2009a; 75:121−6.

Zhang W, Di D, Wen B, Liu X, Jiang S. Determination of scutellarin in *Scutellaria barbata* extract by liquid chromatography-electrochemical detection. J Liq Chromatogr Rel Technol, 2003; 26:2133−40.

Zhang ZF, Wang JG, An J, Zhang H. Determination of scutellarin in *Erigeron acer* from different habitats by RP-HPLC. West China J Pharm Sci, 2009b; 1:36.

Zhu PT, Mao M, Liu ZG, Tao L, Yan BC. Scutellarin suppresses human colorectal cancer metastasis and angiogenesis by targeting ephrinb2. Am J Transl Res, 2017; 9:5094−104.

How to cite this article:
Chan EWC, Lim CSS, Lim WY, Loong ZJ, Wong CW. Role of scutellarin in human cancer—A review. J Appl Pharm Sci, 2019; 9(01):142–146.