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Polygonum capitatum Buch.-Ham. ex D. Don: a review of its phytochemistry

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Abstract

Polygonum capitatum (Polygonaceae) exists in rural areas of Southwest China and some other Asian countries. Its aerial part or whole herbal plant has been used as a Miao ethnomedicine against urinary system diseases, infections, pyelonephritis, diarrhea, and so on. The progress in phytochemical research on *P. capitatum* over the past decades is summarized. Two hundred and three chemical constituents that have been isolated and identified from this plant are included in this article, the chemical structures of which include aliphatic hydrocarbons, aliphatic alcohols, aliphatic ketones, aromatic aldehydes, aliphatic acids, glycerides, triterpenic acids, sterols, anthraquinones, chromones and their glycosides, flavonoids and their glycosides, phenols, phenolic acids and their esters, lignanoids, flavonolignans, phenolic glycosides, alcoholic glycosides, amino acids, nucleobases, amides, alkaloids, alkyl glycosides, volatile oils, and polysaccharides.

Keywords: *Polygonum capitatum*; Polygonaceae; phytochemistry; chemical constituents.

Practical Application: The results of this review provide reference for further research and application of *P. capitatum* and related preparations.

1 Introduction

Polygonum capitatum Buch.-Ham. ex D. Don (Polygonaceae) exists in rural areas of Southwest China and some other Asian countries such as India, Nepal, Bhutan, Burma and Vietnam (Editorial Committee of Chinese Academy of Sciences, 1998). The Chinese names of this perennial herb include "Touhualiao", "Sijihong", "Shijiaocao". The whole plant and the capitate inflorescence of *P. capitatum* are shown in Figure 1. Its aerial part or whole herbal plant (Figure 2) has been used as a Miao ethnomedicine against urinary system diseases and other diseases, including infections, pyelonephritis, urocystitis, urolithiasis, hematuria, rheumatalgia, dysentery, and diarrhea (Nanjing University of Traditional Chinese Medicine, 2006; Pharmaceutical Administration of Guizhou Province, 2003; Ren et al., 1995). The local inhabitants often eat *P. capitatum* on its own as wild vegetables or serve steamed with lean meat (Nanjing University of Traditional Chinese Medicine, 2006; Zhong, 2001). Its leaves and stems can be used as folk dietary medicine (Huang et al., 2008). Relinqing granules, tablets and capsules (Figure 3), which are prepared from *P. capitatum* and approved by the Chinese Food and Drug Administration (Zhang et al., 2013a), not only have the efficacy of "clearing away heat", "reducing fire", "dredging stranguria", and diuresis, but also are used to treat frequent and urgent urination, dysuria, urinary tract infections and pyelonephritis (National Pharmacopoeia Committee, 2020). Relinqing series preparations have been the best-selling Chinese patent medicines on the market to treat urinary system diseases.

Research had showed that the chemical constituents of *P. capitatum* include sterols, triterpenes, alkaloids, lignans, flavonoids, phenolic acids (Chen et al., 2010b; Gao et al., 2001; Li et al., 2000, 2007; Liao et al., 2013; Liu et al., 2008; Wang et al., 2013; Yang et al., 2011, 2015b; Yu et al., 2008; Zhang et al., 2010; Zhao et al., 2010), and other volatile oils (Gao et al., 2005; Wang et al., 2007) and liposoluble compounds (Yang et al., 2009, 2011). Flavonoids and phenolic acids were potentially major active constituents (Zhang et al., 2013a; Zhao et al., 2020). Gallic acid was considered as the best standards as the spectrophotometric response of these compounds were equivalent to most other phenolic acids compounds (Wabaidur et al., 2020). So gallic acid had been used as a marker compound for quality control of Relinqing granules in Chinese Pharmacopoeia (National Pharmacopoeia Committee, 2020).

Reported pharmacological effects of the extracts of *P. capitatum* included analgesis, diuresis (Liu et al., 2007), antioxidation (Huang et al., 2008; Liu et al., 2008; Yan et al., 2010), anti-bacterium (Liao et al., 2011), anti-inflammation (Liao et al., 2011; Zhang et al., 2015), α-glucosidase inhibition (Chen et al., 2010a), antitumor activity (Fu et al., 2012; He et al., 2014; Ma et al., 2014; Wang et al., 2014), and increased activities of CYP2C9 and CYP3A4 (Zheng et al., 2014). Flavonoids and phenolic acids showed antioxidant activity while quercetin, quercitroside and kaempferol were potent enough to clear active oxygen free radicals (Liu et al., 2008). Flavonoids were mentioned to be associated with α-glucosidase inhibition activity

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Figure 1. The whole plant and the capitate inflorescence of *P. capitatum*.

Figure 2. The dried medicinal materials of *P. capitatum*.

Figure 3. Chinese patent medicines: Relinqing granules, tablets and capsules.

(Syabana et al., 2021). Phenolic acids had been shown to have a functional role due to their high antioxidant activity, that prevented oxidative damages (Hartwig et al., 2020). Chemical fractions rich in flavonoids and tannins possessed bacteriostatic and bactericidal properties, while those rich in triterpenoids, steroids, and flavonoids exhibited anti-inflammatory activity (Liao et al., 2011). Flavonol glycosides showed the effect of repairing gastric injury (Zhang et al., 2015). A lignanoid named (−)-lyoniresinol-9′-O-[6-O-(4-hydroxy-3,5-dimethoxy)-benzoyl]-β-D-glucopyranoside exhibited strong α-glucosidase inhibitory activity (Ye et al., 2017). An ellagitannin named davidiin could inhibit hepatocellular tumor growth both *in vitro* and *in vivo* by targeting the enhancer of zeste homolog 2 (EZH2) and warranted further clinical investigation as a potential anti-hepatocellular carcinoma agent (Wang et al., 2014).

So far, about, 203 chemical constituents have been isolated and identified from *P. capitatum*. The chemical structures include aliphatic hydrocarbons, aliphatic alcohols, aliphatic ketones, aromatic aldehydes, aliphatic acids, glycerides, triterpenic acids, sterols, anthraquinones, chromones and their glycosides, flavonoids and their glycosides, phenols, phenolic acids and their esters, lignanoids, flavonolignans, phenolic glycosides, alcoholic glycosides, amino acids, nucleobases, amides, alkaloids, alkyl glycosides, volatile oils, and polysaccharides. The types of their structures, chemical names, molecular formulas, and parts of the plant from which they were isolated are listed in Table 1. Their chemical structures are shown in Figure 4.

2 Results and discussions

Two aliphatic hydrocarbons (**1**,**2**) (Gao et al., 2005; Yang et al., 2009), four aliphatic alcohols (**3**–**6**) (Wang et al., 2007, 2013; Yang et al., 2009, 2011), two aliphatic ketones (**7**,**8**) (Wu & Wang, 1985), two aromatic aldehydes (**9**,**10**) (Wang et al., 2007; Wu & Wang, 1985; Yu et al., 2008), six aliphatic acids (**11**–**16**) (Wang et al., 2007; Wu & Wang, 1985; Yang et al., 2009; Yu et al.,

Table 1. Chemical constituents isolated from *P. capitatum*.

No.	Structure type and chemical name	Molecular formula	Isolation Part	References
	Aliphatic hydrocarbons and aliphatic alcohols			
1	tricosane	$C_{23}H_{48}$	W	Gao et al., 2005; Yang et al., 2009
2	octacosa-1,27-diene	$C_{28}H_{54}$	W	Yang et al., 2009
3	phytol	$C_{20}H_{40}O$	A,U	Wang et al., 2007, 2013
4	tricosanol	$C_{23}H_{48}O$	W	Yang et al., 2009
5	pentacosanol	$C_{25}H_{52}O$	W	Yang et al., 2009
6	tetracosane-1,3-diol	$C_{24}H_{50}O_2$	W	Yang et al., 2011
	Aliphatic ketones and aromatic aldehydes			
7	24-hydroxy-tetracosanone-3	$C_{24}H_{48}O_2$	W	Wu & Wang, 1985
8	29-hydroxy-nonacosanone-3	$C_{29}H_{58}O_2$	W	Wu & Wang, 1985
9	benzaldehyde	C_7H_6O	W,U	Wang et al., 2007; Wu & Wang, 1985
10	5-hydroxymethyl furfural	$C_6H_6O_3$	A	Yu et al., 2008
	Aliphatic acids			
11	acetic acid	$C_2H_4O_2$	W	Wu & Wang, 1985
12	succinic acid	$C_4H_6O_4$	A	Yu et al., 2008
13	linoleic acid	$C_{18}H_{32}O_2$	W	Wang et al., 2007; Yang et al., 2009
14	hexadecanoic acid	$C_{16}H_{32}O_2$	W	Wang et al., 2007; Yang et al., 2009
15	docosanoic acid	$C_{22}H_{44}O_2$	W	Yang et al., 2009
16	tetracosanoic acid	$C_{24}H_{48}O_2$	W	Yang et al., 2009
	Glycerides			
17	hexadecanoic-2,3-dihydroxypropylester	$C_{19}H_{38}O_4$	W	Yang et al., 2009
18	docosanoic-2,3-dihydroxypropylester	$C_{25}H_{50}O_4$	W	Yang et al., 2009
19	1-[(*E*,*E*)-12,16-eicosadienoyl]-2-[(*E*,*E*)-7,11-octadecadienoyl]-3-stearoylglycerol	$C_{59}H_{106}O_6$	A	Wang et al., 2013
	Triterpenic acids and sterols			
20	oleanolic acid	$C_{30}H_{48}O_3$	W	Huang et al., 2015; Yang et al., 2009
21	ursolic acid	$C_{30}H_{48}O_3$	W	Huang et al., 2015; Yang et al., 2009
22	β-sitosterol	$C_{29}H_{50}O$	A,W	Chen et al., 2011; Liu et al., 2008; Wang et al., 2013; Wu & Wang, 1985; Yang et al., 2009
23	daucosterol	$C_{35}H_{60}O_6$	A,W	Chen et al., 2011; Liu et al., 2008; Wang et al., 2013; Yang et al., 2011, 2015b; Zhao et al., 2011
24	24-methylenecycloartenol	$C_{31}H_{52}O$	A	Wang et al., 2013
25	(24*R*)-cycloart-25-ene-3β,24-diol	$C_{30}H_{50}O_2$	W	Yang et al., 2011
	Anthraquinones			
26	emodin	$C_{15}H_{10}O_5$	W	Huang et al., 2015; Yang et al., 2011, 2015b
27	1,5,7-trihydroxyl-3-methylanthraquinone	$C_{15}H_{10}O_5$	A	Yu et al., 2008
28	1,3,8-trihydroxyl-6-methylanthraquinone-1-O-[4-hydroxy-*E*-cinnamoyl-(→2)]-β-D-glucopyranoside	$C_{30}H_{26}O_{12}$	W	Yao et al., 2018
	Chromones and their glycosides, flavonoids and their glycosides			
29	5,7-dihydroxy-4H-chromen-4-one	$C_9H_6O_4$	A,W,U	Liao et al., 2013; Wang et al., 2013; Zhang et al., 2010, 2012
30	5,7-dihydroxychromone-7-O-glucopyranoside	$C_{15}H_{16}O_9$	W	Liao et al., 2013
31	7-O-(6′-galloyl)-β-D-glucopyranosyl-5-hydroxychromone	$C_{22}H_{20}O_{13}$	A,W	Chen et al., 2011; Li et al., 2007; Liao et al., 2012, 2013
32	sawarachromone	$C_{15}H_{14}O_7$	W	Liao et al., 2013
33	luteolin	$C_{15}H_{10}O_6$	A,W	Jing et al., 2015; Zhang et al., 2013b
34	luteolin-7-O-glucoside	$C_{21}H_{20}O_{11}$	W	Wang & Jiang, 2018
35	daidzin	$C_{21}H_{20}O_9$	W	Jing et al., 2015
36	naringenin-7-O-glucopyranoside	$C_{21}H_{22}O_{10}$	W	Liao et al., 2013
37	2,7,4′-trihydroxyflavanone-5-O-β-D-glucopyranoside	$C_{21}H_{22}O_{11}$	W	Yang et al., 2017b
38	kaempferol	$C_{15}H_{10}O_6$	A,W	Jing et al., 2015; Liao et al., 2013; Liu et al., 2008; Wang et al., 2013; Yang et al., 2015b; Yu et al., 2008; Zhang et al., 2012, 2013a, b

Notes: S, stem; L, leave; A, aerial parts; W, whole plant; U, undescribed.

Table 1. Continued...

No.	Structure type and chemical name	Molecular formula	Isolation Part	References
39	kaempferol-3-O-α-L-rhamnopyranoside	$C_{21}H_{20}O_{10}$	S,L,A,W	Huang et al., 2008, 2015; Liao et al., 2013; Wang et al., 2013; Yang et al., 2015b; Zhang et al., 2012
40	kaempferol-3-O-β-D-glucopyranoside	$C_{21}H_{20}O_{11}$	A,W	Huang et al., 2015; Liao et al., 2013; Wang et al., 2013; Yang et al., 2015b
41	kaempferol-3-O-galactoside	$C_{21}H_{20}O_{11}$	W	Liao et al., 2013
42	kaempferol-4′-O-rutinoside	$C_{27}H_{30}O_{15}$	W	Liao et al., 2013
43	quercetin	$C_{15}H_{10}O_{7}$	A,W,U	Huang et al., 2015; Jing et al., 2015; Li et al., 2000; Liao et al., 2013; Liu et al., 2008; Wang et al., 2013; Yang et al., 2015b; Yu et al., 2008; Zhang et al., 2010, 2012, 2013a, b; Zhao et al., 2011; Zheng et al., 2014
44	quercetin 3-methyl ether	$C_{16}H_{12}O_{7}$	A,W	Huang et al., 2015; Liao et al., 2013; Wang et al., 2013
45	quercetin-3-O-arabinoside	$C_{20}H_{18}O_{11}$	S,L,W	Huang et al., 2008; Liao et al., 2013; Yao et al., 2018
46	quercetin-3-O-xyloside	$C_{20}H_{18}O_{11}$	W	Liao et al., 2013
47	quercitroside	$C_{21}H_{20}O_{11}$	S,L,A,W,U	He et al., 2014; Huang et al., 2008, 2015, 2019; Jing et al., 2015; Li et al., 2000, 2007; Liao et al., 2013; Liu et al., 2008;Wang et al., 2013; Wang & Jiang, 2018; Yang et al., 2008, 2015a, b; Yao et al., 2018; Yu et al., 2008; Zhang et al., 2010, 2012, 2013a, b; Zhao et al., 2011; Zheng et al., 2014; Zhou et al., 2017
48	4″-methoxy quercitroside	$C_{22}H_{22}O_{11}$	W	Huang et al., 2015
49	4″-O-acetyl quercitroside	$C_{23}H_{22}O_{12}$	W	Liao et al., 2012, 2013; Zhao et al., 2011
50	quercetin-3-O-(2″-O-protocatechuoyl)-L-rhamnopyranoside	$C_{28}H_{24}O_{14}$	W	Liao et al., 2012, 2013
51	2″-O-galloyl quercitroside	$C_{28}H_{24}O_{15}$	A,W,U	Wang et al., 2013; Yang et al., 2015b; Huang et al., 2015; Liao et al., 2012, 2013; Li et al., 2000; Yao et al., 2018; Zhang et al., 2010, 2012; Zhao et al., 2011; Zhou et al., 2017
52	3″-O-galloyl quercitroside	$C_{28}H_{24}O_{15}$	W	Liao et al., 2012, 2013; Zhang et al., 2012
53	isoquercitrin	$C_{21}H_{20}O_{12}$	S,L,W,U	Huang et al., 2008, 2015; Li et al., 2000; Liao et al., 2013; Liu et al., 2008; Yang et al., 2015b; Yao et al., 2018; Zhang et al., 2010, 2012; Zheng et al., 2014; Zhou et al., 2017
54	quercetin-3-O-β-D-glucuronide	$C_{21}H_{18}O_{13}$	S,L	Huang et al., 2008
55	2″-O-galloyl isoquercitrin	$C_{28}H_{24}O_{16}$	A,W	Huang et al., 2015; Liao et al., 2012, 2013; Wang et al., 2013; Yang et al., 2015b; Yao et al., 2018; Zhang et al., 2012; Zhou et al., 2017
56	3″-O-galloyl isoquercitrin	$C_{28}H_{24}O_{16}$	W	Liao et al., 2012, 2013; Zhang et al., 2012
57	quercetin-3-O-(2″-O-*trans*-*p*-coumaroyl) glucopyranoside	$C_{30}H_{26}O_{14}$	W	Liao et al., 2012, 2013
58	quercetin-3-O-β-D-galactopyranoside	$C_{21}H_{20}O_{12}$	W	Liao et al., 2013; Yang et al., 2015a
59	quercetin-3-O-(2″-O-*trans*-*p*-coumaroyl) galactopyranoside	$C_{30}H_{26}O_{14}$	W	Liao et al., 2012, 2013
60	quercetin-3-O-(6″-O-*trans*-feruloyl)-β-D-galactopyranoside	$C_{31}H_{28}O_{15}$	A	Wang et al., 2013
61	rutin	$C_{27}H_{30}O_{16}$	A,W,U	Jing et al., 2015; Liao et al., 2013; Wang & Jiang, 2018; Zhang et al., 2010, 2012, 2013b
62	myricitrin	$C_{21}H_{20}O_{12}$	A,W	Jing et al., 2015; Liao et al., 2013; Wang et al., 2013; Yang et al., 2015a; Zhang et al., 2012; Zhao et al., 2011; Zheng et al., 2014
63	3,3′,4′,5,5′,7-hexahydroxyflavone-3-O-(5-O-acetyl-L-arabinoside)	$C_{22}H_{20}O_{13}$	W	Yao et al., 2018

Notes: S, stem; L, leave; A, aerial parts; W, whole plant; U, undescribed.

Table 1. Continued...

No.	Structure type and chemical name	Molecular formula	Isolation Part	References
64	3′-hydroxy-3,4′,5,5′,8-pentamethoxy-6,7-methylene dioxyflavone	$C_{21}H_{20}O_{10}$	W	Yao et al., 2018
65	3′,4′-methylenedioxy-3,5,6,7,8,5′-hexamethoxyflavone	$C_{22}H_{22}O_{10}$	W	Gao et al., 2001
66	viviparum B	$C_{23}H_{22}O_{12}$	W	Yao et al., 2018; Zhou et al., 2017
67	taxifolin	$C_{15}H_{12}O_{7}$	W	Huang et al., 2015
68	(−)-epicatechin	$C_{15}H_{14}O_{6}$	W	Yang et al., 2015b
69	(+)-catechin	$C_{15}H_{14}O_{6}$	A,W	Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b; Yao et al., 2018; Zhang et al., 2013a, b; Zhou et al., 2017
70	(−)-epicatechin-3-O-gallate	$C_{22}H_{18}O_{10}$	W	Huang et al., 2015; Zhou et al., 2017
71	(+)-catechin-3-O-gallate	$C_{22}H_{18}O_{10}$	W	Yang et al., 2015b
72	(−)-epicatechin-(2β→O→7,4β→8)-(+)-catechin (procyanidin A1)	$C_{30}H_{24}O_{12}$	W	Yang et al., 2015b
73	3-galloyl-(−)-epicatechin-(4β→8)-3-galloyl-(−)-epicatechin (3,3″-digalloylprocyanidin B2)	$C_{44}H_{34}O_{20}$	W	Yao et al., 2018; Zhou et al., 2017
	Phenols, phenolic acids and their esters			
74	catechol	$C_{6}H_{6}O_{2}$	U	Zhang et al., 2010
75	*p*-hydroxybenzoic acid	$C_{7}H_{6}O_{3}$	A	Wang et al., 2013
76	gentisic acid	$C_{7}H_{6}O_{4}$	W	Jing et al., 2015
77	protocatechuic acid	$C_{7}H_{6}O_{4}$	A,W,U	Chen et al., 2011; Huang et al., 2019; Jing et al., 2015; Li et al., 2007; Liao et al., 2013; Liu et al., 2008; Yang et al., 2015a, b; Yu et al., 2008; Zhang et al., 2010, 2013a, b; Zhao et al., 2011; Zheng et al., 2014
78	vanillic acid	$C_{8}H_{8}O_{4}$	A	Chen et al., 2011; Li et al., 2007; Yu et al., 2008; Zhang et al., 2013a, b
79	ethyl protocatechuate	$C_{9}H_{10}O_{4}$	A,U	Wang et al., 2013; Yu et al., 2008; Zhang et al., 2010
80	gallic acid	$C_{7}H_{6}O_{5}$	S,L,A,W,U	Chen et al., 2010b, 2011; Huang et al., 2008, 2019; Liao et al., 2013; Liu et al., 2008; Wang et al., 2013; Wu & Wang, 1985; Yang et al., 2008, 2015a, b; Yu et al., 2008; Zhang et al., 2010; 2013a, b; Zhao et al., 2011; Zheng et al., 2014; Zhou et al., 2017
81	3,5-dihydroxy-4-methoxybenzoic acid	$C_{8}H_{8}O_{5}$	W,U	Liao et al., 2013; Zhang et al., 2010
82	syringic acid	$C_{9}H_{10}O_{5}$	A,U	Zhang et al., 2010, 2013a, b
83	methyl gallate	$C_{8}H_{8}O_{5}$	A,W	Jing et al., 2015; Zhang et al., 2013b
84	ethyl gallate	$C_{9}H_{10}O_{5}$	A,W,U	Huang et al., 2015; Liu et al., 2008; Wang et al., 2013; Yang et al., 2015b; Yu et al., 2008; Zhang et al., 2010, 2013b; Zhao et al., 2011
85	ellagic acid	$C_{14}H_{6}O_{8}$	A,W	Liao et al., 2013; Wang et al., 2013; Zhang et al., 2012; Zhou et al., 2017
86	3,3′-di-O-methylellagic acid	$C_{16}H_{10}O_{8}$	W	Liao et al., 2013; Zhou et al., 2017
87	brevifolin	$C_{12}H_{8}O_{6}$	A	Wang et al., 2013
88	brevifolin carboxylic acid	$C_{13}H_{8}O_{8}$	U	Chen et al., 2010b
89	ethyl brevifolin carboxylate	$C_{15}H_{12}O_{8}$	A	Wang et al., 2013
90	3-O-galloyl-α-D-glucopyranoside	$C_{13}H_{16}O_{10}$	W	Yang et al., 2015b
91	3-O-galloyl-β-D-glucopyranoside	$C_{13}H_{16}O_{10}$	W	Yang et al., 2015b
92	6-O-galloyl-D-glucopyranoside	$C_{13}H_{16}O_{10}$	W	Yao et al., 2018
93	3,6-O-digalloyl-D-glucopyranoside	$C_{20}H_{20}O_{14}$	W	Yao et al., 2018; Zhou et al., 2017
94	1,3,6-O-trigalloyl-D-glucopyranoside	$C_{27}H_{24}O_{18}$	W	Yao et al., 2018
95	1,3-di-O-galloyl-4,6-O-(*S*)-hexahydroxy-diphenoyl-β-D-glucopyranoside	$C_{34}H_{26}O_{22}$	W	Yao et al., 2018; Zhou et al., 2017

Notes: S, stem; L, leave; A, aerial parts; W, whole plant; U, undescribed.

Table 1. Continued...

No.	Structure type and chemical name	Molecular formula	Isolation Part	References
96	davidiin	$C_{41}H_{30}O_{26}$	W	Fu et al., 2012; He et al., 2014; Ma et al., 2014; Wang et al., 2014; Yang et al., 2008; Yao et al., 2018; Zhou et al., 2017
97	*trans-p*-coumaric acid	$C_9H_8O_3$	W	Liao et al., 2013
98	docosyl ferulate	$C_{32}H_{54}O_4$	W	Yang et al., 2009
99	tetracosyl ferulate	$C_{34}H_{58}O_4$	W	Liu et al., 2008
100	chlorogenic acid	$C_{16}H_{18}O_9$	S,L	Huang et al., 2008
101	helonioside A	$C_{32}H_{38}O_{17}$	W	Yao et al., 2018; Zhou et al., 2017
102	6-acetyl-3′,6′-O-diferuloylsucrose (helonioside B)	$C_{34}H_{40}O_{18}$	W	Zhou et al., 2017
103	bistoroside B	$C_{34}H_{40}O_{18}$	W	Liao et al., 2013
	Lignanoids and flavonolignans			
104	(+)-isolariciresinol	$C_{20}H_{24}O_6$	W	Ye et al., 2017
105	schizandriside	$C_{25}H_{32}O_{10}$	A,W	Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b; Yao et al., 2018; Zhang et al., 2013a, b; Zhao et al., 2010; Zhou et al., 2017
106	5′-methoxy-(+)-isolariciresinol-9′-O-β-D-xylopyranoside	$C_{26}H_{34}O_{11}$	W	Huang et al., 2015; Ye et al., 2017
107	lyoniside	$C_{27}H_{36}O_{12}$	W	Ye et al., 2017
108	(+)-isolariciresinol-9′-O-β-D-glucopyranoside	$C_{26}H_{34}O_{11}$	W	Huang et al., 2015
109	(+)-lyoniresinol-9′-O-β-D-glucopyranoside	$C_{28}H_{38}O_{13}$	W	Zhou et al., 2017
110	(−)-isolariciresinol	$C_{20}H_{24}O_6$	W	Huang et al., 2015
111	(−)-isolariciresinol-9′-O-β-D-xylopyranoside	$C_{25}H_{32}O_{10}$	W	Yang et al., 2015b; Ye et al., 2017; Zhao et al., 2010
112	5′-methoxy-(−)-isolariciresinol-9′-O-β-D-xylopyranoside	$C_{26}H_{34}O_{11}$	W	Yang et al., 2015b; Zhao et al., 2010
113	nudiposide	$C_{27}H_{36}O_{12}$	W	Huang et al., 2015; Yang et al., 2015b; Yao et al., 2018; Ye et al., 2017; Zhao et al., 2010; Zhou et al., 2017
114	(−)-isolariciresinol-9′-O-β-D-glucopyranoside	$C_{26}H_{34}O_{11}$	W	Ye et al., 2017
115	(−)-lyoniresinol-9′-O-[6-O-(4-hydroxy-3,5-dimethoxy)-benzoyl]-β-D-glucopyranoside	$C_{37}H_{46}O_{17}$	W	Ye et al., 2017
116	silibinin	$C_{25}H_{22}O_{10}$	W	Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b
117	2,3-dehydrosilibinin	$C_{25}H_{20}O_{10}$	W	Huang et al., 2015; Yang et al., 2015b
118	silychristin	$C_{25}H_{22}O_{10}$	W	Yang et al., 2015b
119	2,3-dehydrosilychristin	$C_{25}H_{20}O_{10}$	W	Huang et al., 2015; Yang et al., 2015b
	Phenolic glycosides			
120	arbutin	$C_{12}H_{16}O_7$	W	Huang et al., 2015; Yang et al., 2017b
121	3-methoxyl-4-hydroxyphenol-1-O-β-D-glucopyranoside (tachioside)	$C_{13}H_{18}O_8$	W	Huang et al., 2015; Yang et al., 2017b
122	3-methoxyl-4-hydroxyphenol-1-O-β-D-(6′-O-galloyl)glucopyranoside	$C_{20}H_{22}O_{12}$	W	Yang et al., 2017b
123	2-methoxyl-4-hydroxyphenol-1-O-β-D-glucopyranoside (isotachioside)	$C_{13}H_{18}O_8$	W	Huang et al., 2015; Yang et al., 2017b
124	2-methoxyl-4-hydroxyphenol-1-O-β-D-(6′-O-galloyl)glucopyranoside	$C_{20}H_{22}O_{12}$	W	Yang et al., 2017b
125	3,5-dimethoxyl-4-hydroxyphenol-1-O-β-D-glucopyranoside	$C_{14}H_{20}O_9$	W	Huang et al., 2015; Yang et al., 2017b
126	3,4,5-trimethoxylphenol-1-O-β-D-glucopyranoside	$C_{15}H_{22}O_9$	W	Yang et al., 2017b
127	3-methoxyl-5-hydroxyphenol-1-O-β-D-glucopyranoside (picraquassioside D)	$C_{13}H_{18}O_8$	W	Huang et al., 2015; Yang et al., 2017b
128	3-methoxyl-5-hydroxyphenol-1-O-β-D-(6′-O-galloyl)glucopyranoside	$C_{20}H_{22}O_{12}$	W	Liao et al., 2012, 2013; Zhang et al., 2012
129	3-methoxyl-5-hydroxyphenol-1-O-β-D-(6′-O-galloyl)galactopyranoside	$C_{20}H_{22}O_{12}$	W	Liao et al., 2012, 2013

Notes: S, stem; L, leave; A, aerial parts; W, whole plant; U, undescribed.

Table 1. Continued...

No.	Structure type and chemical name	Molecular formula	Isolation Part	References
	Alcoholic glycosides			
130	benzyl-O-β-D-glucopyranoside	$C_{13}H_{18}O_6$	W	Yang et al., 2017b
131	salidroside	$C_{14}H_{20}O_7$	W	Huang et al., 2015; Yang et al., 2017b
132	β-D-glucopyranosyl-12-hydroxyjasmonic acid	$C_{18}H_{28}O_9$	W	Yang et al., 2017b
133	β-D-glucopyranosyl-12-hydroxy-12-(2″-hydroxy-2″-carboxyethyl)jasmonic acid	$C_{21}H_{32}O_{12}$	W	Yang et al., 2017b
	Amino acids, nucleobases, amides and alkaloids			
134	L-phenylalanine	$C_9H_{11}NO_2$	W	Jing et al., 2015; Liao et al., 2013
135	L-tryptophan	$C_{11}H_{12}N_2O_2$	W	Yang et al., 2017b
136	uracil	$C_4H_4N_2O_2$	W	Jing et al., 2015
137	N-*trans*-caffeoyltyramine	$C_{17}H_{17}NO_4$	A	Wang et al., 2013
138	N-*cis*-feruloyltyramine	$C_{18}H_{19}NO_4$	W	Liao et al., 2013
139	flazine	$C_{17}H_{12}N_2O_4$	A	Wang et al., 2013
	Alkyl glycosides			
140	2-O-butyl-α-D-fructofuranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2011, 2017a
141	2-O-butyl-β-D-fructofuranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2011, 2017a
142	2-O-butyl-β-D-fructopyranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2017a
143	3-O-butyl-β-D-fructopyranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2017a
144	1-O-butyl-α-D-glucofuranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2017a
145	1-O-butyl-β-D-glucofuranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2017a
146	1-O-butyl-β-D-glucopyranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2017a
147	1-O-butyl-β-D-mannopyranoside	$C_{10}H_{20}O_6$	W	Yang et al., 2011
	Volatile oils			
148	*trans*-β-farnesene	$C_{15}H_{24}$	W	Gao et al., 2005
149	1-hexanol	$C_6H_{14}O$	W	Gao et al., 2005
150	3-octanol	$C_8H_{18}O$	W	Gao et al., 2005
151	(*E*)-2-octen-1-ol	$C_8H_{16}O$	W	Gao et al., 2005
152	1-octen-3-ol	$C_8H_{16}O$	W	Gao et al., 2005
153	(*Z*)-1,5-octadien-3-ol	$C_8H_{14}O$	W	Gao et al., 2005
154	nerolidol	$C_{15}H_{26}O$	W	Gao et al., 2005
155	heptanal	$C_7H_{14}O$	W	Gao et al., 2005
156	*n*-octanal	$C_8H_{16}O$	W	Gao et al., 2005
157	nonanal	$C_9H_{18}O$	W	Gao et al., 2005
158	2-hexenal	$C_6H_{10}O$	W	Gao et al., 2005
159	(*E*)-2-heptenal	$C_7H_{12}O$	W	Gao et al., 2005
160	(*E*)-2-octenal	$C_8H_{14}O$	W	Gao et al., 2005
161	(*E*,*E*)-2,4-heptadienal	$C_7H_{10}O$	W	Gao et al., 2005
162	2-heptanone	$C_7H_{14}O$	W	Gao et al., 2005
163	6-methyl-5-hepten-2-one	$C_8H_{14}O$	W	Gao et al., 2005
164	1-octen-3-one	$C_8H_{14}O$	W	Gao et al., 2005
165	2,3-octanedione	$C_8H_{14}O_2$	W	Gao et al., 2005
166	6,10,14-trimethyl-2-pentadecanone	$C_{18}H_{36}O$	W,U	Gao et al., 2005; Wang et al., 2007
167	*p*-xylene	C_8H_{10}	W	Gao et al., 2005
168	anthracene	$C_{14}H_{10}$	W	Gao et al., 2005
169	2-pentyl-furan	$C_9H_{14}O$	W	Gao et al., 2005
170	hyacinthin	C_8H_8O	W	Gao et al., 2005
171	2,2,6-trimethyl-cyclohexanone	$C_9H_{16}O$	W	Gao et al., 2005
172	β-cyclocitral	$C_{10}H_{16}O$	W	Gao et al., 2005
173	precocene I	$C_{12}H_{14}O_2$	W	Gao et al., 2005
174	β-costol	$C_{15}H_{24}O$	W	Gao et al., 2005
175	γ-costol	$C_{15}H_{24}O$	W	Gao et al., 2005
176	m-menthe-1,8-diene	$C_{10}H_{16}$	W	Gao et al., 2005
177	limonene	$C_{10}H_{16}$	W	Gao et al., 2005

Notes: S, stem; L, leave; A, aerial parts; W, whole plant; U, undescribed.

Table 1. Continued...

No.	Structure type and chemical name	Molecular formula	Isolation Part	References
178	α-terpinolene	$C_{10}H_{16}$	W	Gao et al., 2005
179	terpinene-4-ol	$C_{10}H_{18}O$	W	Gao et al., 2005
180	α-terpineol	$C_{10}H_{18}O$	W,U	Gao et al., 2005; Wang et al., 2007
181	1-menthol	$C_{10}H_{20}O$	W	Gao et al., 2005
182	*o*-cymene	$C_{10}H_{14}$	W	Gao et al., 2005
183	carvacrol	$C_{10}H_{14}O$	W	Gao et al., 2005
184	α-pinene	$C_{10}H_{16}$	W	Gao et al., 2005
185	nopinone	$C_9H_{14}O$	W	Gao et al., 2005
186	myrtenal	$C_{10}H_{14}O$	W	Gao et al., 2005
187	camphene	$C_{10}H_{16}$	W,U	Gao et al., 2005; Wang et al., 2007
188	L-borneol	$C_{10}H_{18}O$	W	Gao et al., 2005
189	1,8-cineole	$C_{10}H_{18}O$	W	Gao et al., 2005
190	camphore	$C_{10}H_{16}O$	W	Gao et al., 2005
191	β-caryophyllene	$C_{15}H_{24}$	W	Gao et al., 2005
192	δ-cadinene	$C_{15}H_{24}$	W	Gao et al., 2005
193	γ-gurjunene	$C_{15}H_{24}$	W	Gao et al., 2005
194	longiborneol	$C_{15}H_{26}O$	W	Gao et al., 2005
195	globulol	$C_{15}H_{26}O$	W	Gao et al., 2005
196	lauric acid	$C_{12}H_{24}O_2$	U	Wang et al., 2007
197	myristic acid	$C_{14}H_{28}O_2$	U	Wang et al., 2007
198	pentadecanoic acid	$C_{15}H_{30}O_2$	U	Wang et al., 2007
199	oleic acid	$C_{18}H_{34}O_2$	U	Wang et al., 2007
200	methyl-9-octadecenoate	$C_{19}H_{36}O_2$	U	Wang et al., 2007
201	methyl linoleate	$C_{19}H_{34}O_2$	U	Wang et al., 2007
202	methyl linolenate	$C_{19}H_{32}O_2$	U	Wang et al., 2007
203	tetracosane	$C_{24}H_{50}$	W	Gao et al., 2005

Notes: S, stem; L, leave; A, aerial parts; W, whole plant; U, undescribed.

2008), and three glycerides (**17**–**19**) (Wang et al., 2013; Yang et al., 2009) were identified from the aerial parts or whole plant of *P. capitatum*. All were isolated from petroleum ether extracts.

Two pentacyclic triterpenic acids, which are named oleanolic acid (**20**) (Huang et al., 2015; Yang et al., 2009) and ursolic acid (**21**) (Huang et al., 2015; Yang et al., 2009) are of the oleanane type and ursane type of triterpenes respectively, were found from the whole plant of *P. capitatum*. Four sterols (**22**–**25**) (Chen et al., 2011; Liu et al., 2008; Wang et al., 2013; Wu & Wang, 1985; Yang et al., 2009, 2011, 2015b; Zhao et al., 2011) were isolated from the aerial parts and whole plant. β-Sitosterol (**22**) and daucosterol (**23**) are extremely common in higher plants. Isolation of (24*R*)-cycloart-25-ene-3β,24-diol (**25**) from Polygonaceae was reported for the first time in, 2011 (Yang et al., 2011). Three anthraquinones (**26**–**28**) (Huang et al., 2015; Yang et al., 2011, 2015b; Yao et al., 2018; Yu et al., 2008) were isolated from *P. capitatum*.

Four chromones (**29**–**32**) (Chen et al., 2011; Li et al., 2007; Liao et al., 2012, 2013; Wang et al., 2013; Zhang et al., 2010, 2012), namely benzo-γ-pyron compounds, were obtained from *P. capitatum*. 7-O-(6′-Galloyl)-β-D-glucopyranosyl-5-hydroxychromone (**31**) (Chen et al., 2011; Li et al., 2007; Liao et al., 2012, 2013), a derivative of 5,7-dihydroxychromone-7-O-glucopyranoside (**30**) (Liao et al., 2013), was a new structure chromone that was found from *P. capitatum* and reported in, 2007 for the first time. Benzo-γ-pyron can be considered the parent nucleus of flavonoids. Flavonoids in *P. capitatum* have been found to be effective constituents and fall into six major types: flavone, isoflavone, flavanone, flavonol, flavanonol, and flavan-3-ol. Two flavones named luteolin (**33**) (Jing et al., 2015; Zhang et al., 2013b) and luteolin-7-O-glucoside (**34**) (Wang & Jiang, 2018), and one isoflavone named daidzin (**35**) (Jing et al., 2015) were isolated from *P. capitatum*. Twenty-nine flavonols (**38**–**66**) were isolated from various parts of *P. capitatum* and were of the same structure. Among them were four glycosides (**39**–**42**) (Huang et al., 2008, 2015; Liao et al., 2013; Wang et al., 2013; Yang et al., 2015b; Zhang et al., 2012) of kaempferol (**38**) (Jing et al., 2015; Liao et al., 2013; Liu et al., 2008; Wang et al., 2013; Yang et al., 2015b; Yu et al., 2008; Zhang et al., 2012, 2013a, b), one methylation product named 3-O-methylquercetin (**44**) (Huang et al., 2015; Liao et al., 2013; Wang et al., 2013) and seventeen glycosides (**45**–**61**) of quercetin (**43**) (He et al., 2014; Huang et al., 2008, 2015, 2019; Jing et al., 2015; Li et al., 2000, 2007; Liao et al., 2012, 2013; Liu et al., 2008; Wang et al., 2013; Wang & Jiang, 2018; Yang et al., 2008, 2015a, b; Yao et al., 2018; Yu et al., 2008; Zhang et al., 2010, 2012, 2013a, b; Zhao et al., 2011; Zheng et al., 2014; Zhou et al., 2017). Myricitrin (**62**) (Jing et al., 2015; Liao et al., 2013; Wang et al., 2013; Yang et al., 2015a; Zhang et al., 2012; Zhao et al., 2011; Zheng et al., 2014) and

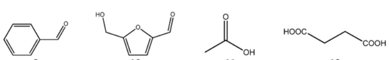
	R_1	R_2	R_3
1	H	H	H
4	H	OH	H
5	CH_2CH_3	OH	H
6	CH_3	OH	OH
203	CH_3	H	H

3

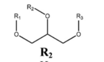
2

	R_1	R_2
7	n-$C_6H_{12}CH_2OH$	CH_2CH_3
8	n-$C_{11}H_{22}CH_2OH$	CH_2CH_3
14	CH_3	OH
15	n-C_7H_{15}	OH
16	n-C_9H_{19}	OH

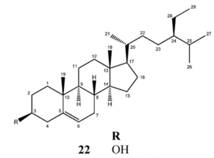
13



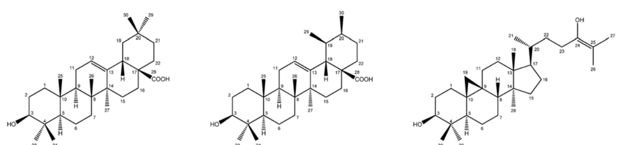
9 **10** **11** **12**



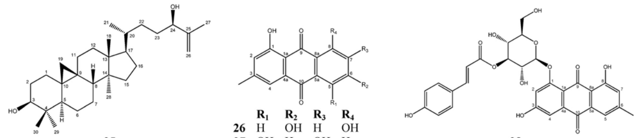
	R_1	R_2	R_3
17	hexadecanoyl	H	H
18	docosanoyl	H	H
19	(E,E)-12,16-eicosadienoyl	(E,E)-7,11-octadecadienoyl	stearoyl



	R
22	OH
23	O-β-D-Glu



20 **21** **24**



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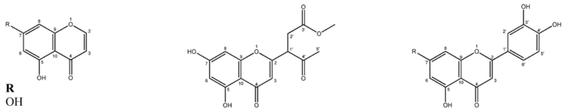
	R_1	R_2	R_3	R_4
26	H	OH	H	OH
27	OH	H	OH	H

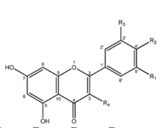
28



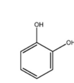
	R
29	OH
30	O-Glu
31	O-β-D-(6″-O-galloyl)-Glu

32

	R
33	OH
34	O-Glu



	R_1	R_2	R_3	R_4
38	H	OH	H	OH
39	H	OH	H	O-α-L-Rha
40	H	OH	H	O-β-D-Glu
41	H	OH	H	O-Gal
42	H	O-Rut	H	OH
43	H	OH	OH	OH
44	H	OH	OH	OCH_3
45	H	OH	OH	O-Ara
46	H	OH	OH	O-Xyl
47	H	OH	OH	O-α-L-Rha
48	H	OH	OH	O-α-L-(4″-methoxy)-Rha
49	H	OH	OH	O-α-L-(4″-O-acyel)-Rha
50	H	OH	OH	O-α-L-(2″-O-protocatechuoyl)-Rha
51	H	OH	OH	O-α-L-(2″-O-galloyl)-Rha
52	H	OH	OH	O-α-L-(3″-O-galloyl)-Rha
53	H	OH	OH	O-β-D-Glu
54	H	OH	OH	O-β-D-glucuronide
55	H	OH	OH	O-β-D-(2″-O-galloyl)-Glu
56	H	OH	OH	O-β-D-(3″-O-galloyl)-Glu
57	H	OH	OH	O-(2″-O-*trans*-*p*-coumaroyl)-Glu
58	H	OH	OH	O-β-D-Gal
59	H	OH	OH	O-(2″-O-*trans*-*p*-coumaroyl)-Gal
60	H	OH	OH	O-β-D-(6″-O-*trans*-feruloyl)-Gal
61	H	OH	OH	O-Rut
62	OH	OH	OH	O-α-L-Rha



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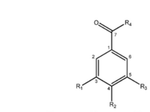
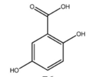


	R_1	R_2	R_3	R_4
75	H	OH	H	OH
77	H	OH	OH	OH
78	H	OH	OCH_3	OH
79	H	OH	OH	OCH_2CH_3
80	OH	OH	OH	OH
81	OH	OCH_3	OH	OH
82	OCH_3	OH	OCH_3	OH
83	OH	OH	OH	OCH_3
84	OH	OH	OH	OCH_2CH_3



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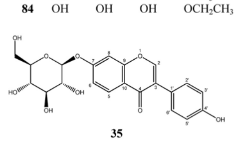

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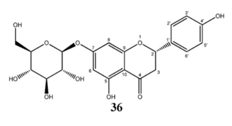

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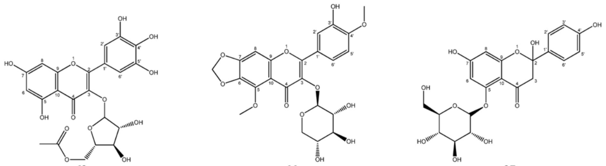
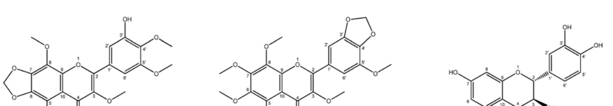
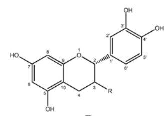


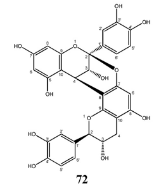
63 **66** **37**



64 **65** **67**



	R
68	α-OH
69	β-OH
70	α-O-galloyl
71	β-O-galloyl



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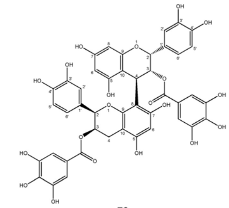

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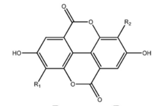
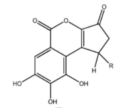
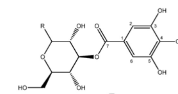


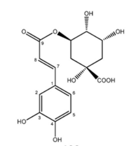
	R_1	R_2
85	OH	OH
86	OCH_3	OCH_3



	R
87	H
88	COOH
89	$COOCH_2CH_3$



	R
90	α-OH
91	β-OH



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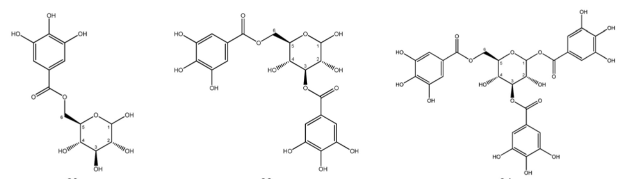
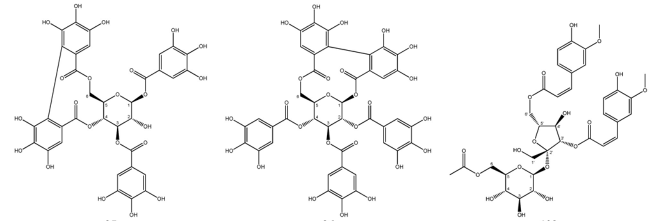
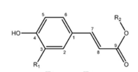


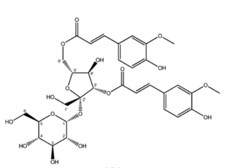
92 **93** **94**



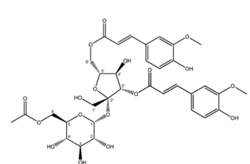
95 **96** **103**



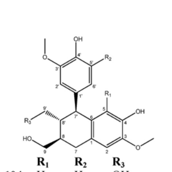
	R_1	R_2
97	H	H
98	OCH_3	n-$C_{22}H_{45}$
99	OCH_3	n-$C_{24}H_{49}$



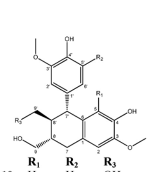
101



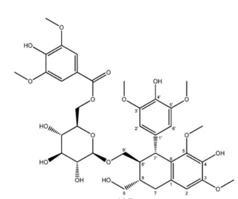
102



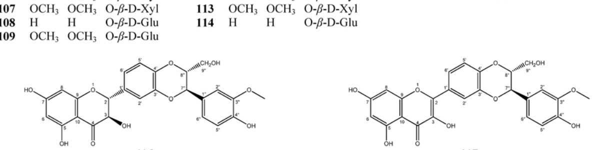
	R_1	R_2	R_3
104	H	H	OH
105	H	H	O-β-D-Xyl
106	H	OCH_3	O-β-D-Xyl
107	OCH_3	OCH_3	O-β-D-Xyl
108	H	H	O-β-D-Glu
109	OCH_3	OCH_3	O-β-D-Glu



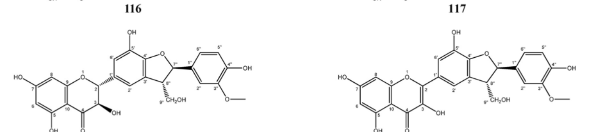
	R_1	R_2	R_3
110	H	H	OH
111	H	H	O-β-D-Xyl
112	H	OCH_3	O-β-D-Xyl
113	OCH_3	OCH_3	O-β-D-Xyl
114	H	H	O-β-D-Glu



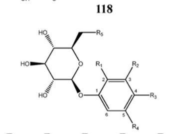
115



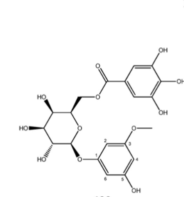
116 **117**



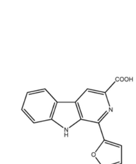
118 **119**



	R_1	R_2	R_3	R_4	R_5
120	H	H	OH	H	OH
121	H	OCH_3	OH	H	OH
122	H	OCH_3	OH	H	O-galloyl
123	OCH_3	H	OH	H	OH
124	OCH_3	H	OH	H	O-galloyl
125	H	OCH_3	OH	OCH_3	OH
126	H	OCH_3	OCH_3	OCH_3	OH
127	H	OCH_3	H	OH	OH
128	H	OCH_3	H	OH	O-galloyl



129



139

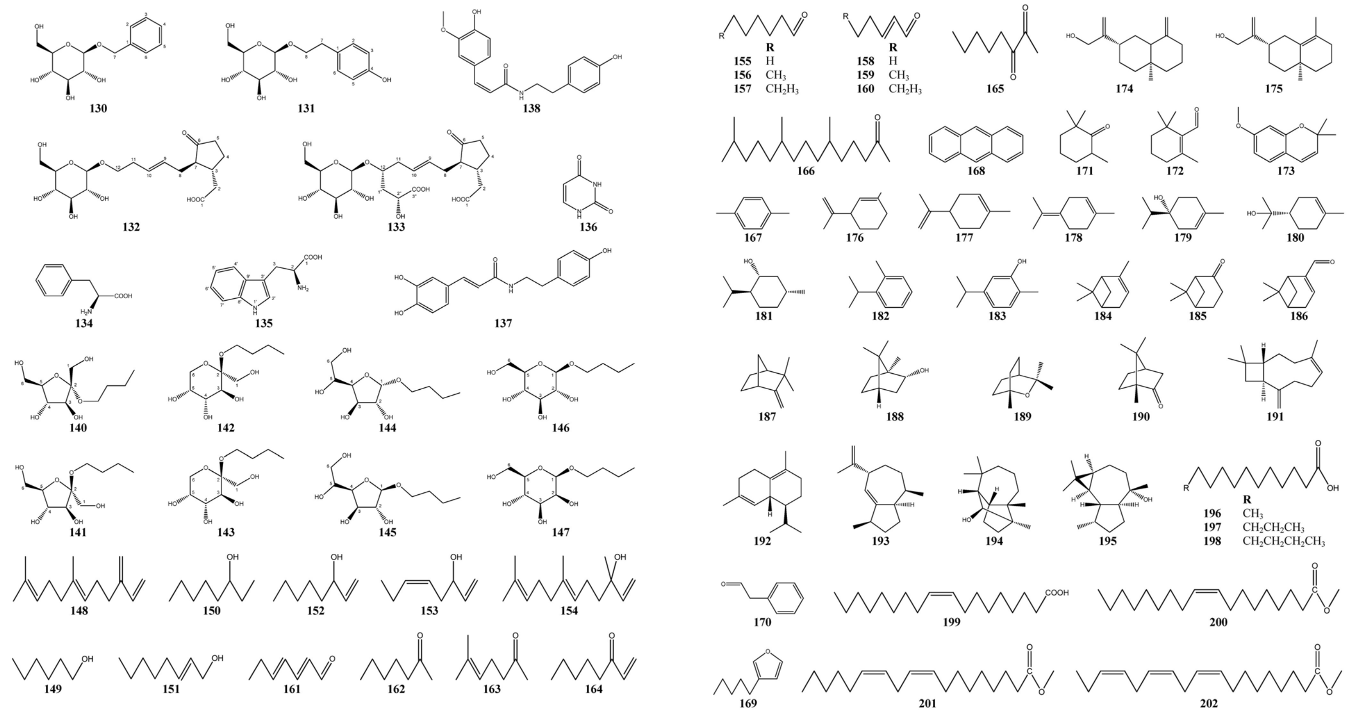


Figure 4. Structures of chemical constituents of *P. capitatum*. Notes: Ara, arabinoside; Xyl, xyloside; Rha, rhamnoside; Glu, glucoside; Gal, galactoside; Rut, rutinoside.

3,3′,4′,5,5′,7-hexahydroxyflavone-3-O-(5-O-acetyl-L-arabinoside) (**63**) (Yao et al., 2018) are two glycosides of myricetin. 3′-Hydroxy-3,4′,5,5′,8-pentamethoxy-6,7-methylenedioxyflavone (**64**) (Yao et al., 2018), 3′,4′-methylenedioxy-3,5,6,7,8,5′-hexamethoxyflavone (**65**) (Gao et al., 2001), and viviparum B (**66**) (Yao et al., 2018; Zhou et al., 2017) all had a methylenedioxy structure. Compound **65** was a new structure flavonol obtained from *P. capitatum* and reported in, 2001 for the first time (Gao et al., 2001). Two flavanones (**36**,**37**) (Liao et al., 2013; Yang et al., 2017b), one flavanonol (**67**) (Huang et al., 2015), and six flavan-3-ols (**68**–**73**) (Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b; Yao et al., 2018; Zhang et al., 2013a, b; Zhou et al., 2017) were also found from *P. capitatum*. 2,7,4′-Trihydroxyflavanone-5-O-β-D-glucopyranoside (**37**) (Yang et al., 2017b) is a 2-hydroxylation product of flavanone. (−)-Epicatechin-(2β→O→7,4β→8)-(+)-catechin (**72**) (Yang et al., 2015b), also named procyanidin A1 and obtained from Polygonaceae for the first time, is a condensation product of (−)-epicatechin (**68**) (Yang et al., 2015b) and (+)-catechin (**69**) (Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b; Yao et al., 2018; Zhang et al., 2013a, b; Zhou et al., 2017). 3-Galloyl-(−)-epicatechin-(4β→8)-3-galloyl-(−)-epicatechin (**73**) (Yao et al., 2018; Zhou et al., 2017), also named 3,3′-digalloylprocyanidin B2, is a condensation product of (−)-epicatechin (**68**) (Yang et al., 2015b).

Catechol (**74**) (Zhang et al., 2010), which belonged to phenols, was obtained from *P. capitatum*. Twenty-nine phenolic acids and their esters (**75**–**103**) were found from *P. capitatum*, including two hydroxylation products of benzoic acid (**75**,**76**) (Jing et al., 2015; Wang et al., 2013), protocatechuic acid (**77**) (Chen et al., 2011; Huang et al., 2019; Jing et al., 2015; Li et al., 2007; Liao et al., 2013; Liu et al., 2008; Yang et al., 2015a, b; Yu et al., 2008; Zhang et al., 2010, 2013a, b; Zhao et al., 2011; Zheng et al., 2014), one methylation product (**78**) (Chen et al., 2011; Li et al., 2007; Yu et al., 2008; Zhang et al., 2013a, b) and one ethyl ester (**79**) (Wang et al., 2013; Yu et al., 2008; Zhang et al., 2010) of protocatechuic acid. Gallic acid (**80**) (Chen et al., 2010b, 2011; Huang et al., 2008, 2019; Liao et al., 2013; Liu et al., 2008; Wang et al., 2013; Wu & Wang, 1985; Yang et al., 2008, 2015a, b; Yu et al., 2008; Zhang et al., 2010, 2013a, b; Zhao et al., 2011; Zheng et al., 2014; Zhou et al., 2017) was found to be another effective constituent of *P. capitatum*. Sixteen derivatives of gallic acid (**81**–**96**) were isolated from the aerial parts or whole plant of *P. capitatum*, including two methylation products (**81**,**82**) (Liao et al., 2013; Zhang et al., 2010, 2013a, b), one methyl ester (**83**) (Jing et al., 2015; Zhang et al., 2013b), and one ethyl ester (**84**) (Huang et al., 2015; Liu et al., 2008; Wang et al., 2013; Yang et al., 2015b; Yu et al., 2008; Zhang et al., 2010, 2013b; Zhao et al., 2011) of gallic acid, two ellagic acids (**85**,**86**) (Liao et al., 2013; Wang et al., 2013; Zhang et al., 2012; Zhou et al., 2017), brevifolin (**87**) (Wang et al., 2013) and two of its derivatives (**88**,**89**) (Chen et al., 2010b; Wang et al., 2013), and seven glucosides (**90**–**96**) (Fu et al., 2012; He et al., 2014; Ma et al., 2014; Wang et al., 2014; Yang et al., 2008, 2015b; Yao et al., 2018; Zhou et al., 2017) of gallic acid. *Trans-p*-coumaric acid (**97**) (Liao et al., 2013), three derivatives (**98**–**100**) (Huang et al., 2008; Liu et al., 2008; Yang et al., 2009) of ferulic acid, and three disubstituted phenylpropanoid sucrose esters (**101**–**103**) (Liao et al., 2013; Yao et al., 2018; Zhou et al., 2017) were obtained from *P. capitatum*. Furthermore, the two flavonol glycosides mentioned above (**55**,**57**) (Liao et al., 2012, 2013; Zhang et al., 2012) also contained the *trans-p*-coumaroyl group.

Twelve lignanoids (**104–115**) (Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b; Yao et al., 2018; Ye et al., 2017; Zhang et al., 2013a, b; Zhao et al., 2010; Zhou et al., 2017) were obtained from the aerial parts or whole plant of *P. capitatum* including five derivatives (**105–109**) (Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b; Yao et al., 2018; Ye et al., 2017; Zhang et al., 2013a, b; Zhao et al., 2010; Zhou et al., 2017) of (+)-isolariciresinol (**104**) (Ye et al., 2017) and five derivatives (**111–115**) (Huang et al., 2015; Yang et al., 2015b; Yao et al., 2018; Ye et al., 2017; Zhao et al., 2010; Zhou et al., 2017) of (−)-isolariciresinol (**110**) (Huang et al., 2015). Isolation of four flavonolignans (**116–119**) (Huang et al., 2015; Jing et al., 2015; Yang et al., 2015b) from this plant was reported for the first time, so was the isolation of flavonolignans from Polygonaceae (Yang et al., 2015b).

Ten phenolic glycosides (**120–129**) (Huang et al., 2015; Liao et al., 2012, 2013; Yang et al., 2017b; Zhang et al., 2012) were obtained from the whole plant of *P. capitatum*. Except 3-methoxyl-5-hydroxyphenol-1-O-β-D-glucopyranoside (**127**) (Huang et al., 2015; Yang et al., 2017b), 3-methoxyl-5-hydroxyphenol-1-O-β-D-(6′-O-galloyl)glucopyranoside (**128**) (Liao et al., 2012, 2013; Zhang et al., 2012), and 3-methoxyl-5-hydroxyphenol-1-O-β-D-(6′-O-galloyl)galactopyranoside (**129**) (Liao et al., 2012, 2013), all the other phenolic glycosides (**121–126**) (Huang et al., 2015; Yang et al., 2017b) can be considered derivatives of arbutin (**120**) (Huang et al., 2015; Yang et al., 2017b), with methoxylations of benzene ring or galloylations of glycoside.

Four alcoholic glycosides (**130–133**) (Huang et al., 2015; Yang et al., 2017b) were obtained from the whole plant of *P. capitatum*. β-D-Glucopyranosyl-12-hydroxy-12-(2″-hydroxy-2″-carboxyethyl)jasmonic acid (**133**), a derivative of β-D-glucopyranosyl-12-hydroxyjasmonic acid (**132**), was a new structure compound reported in, 2017 (Yang et al., 2017b). Both compound **132** and compound **133** are hydroxyjasmonic acid derivatives.

Two amino acids (**134**,**135**) (Jing et al., 2015; Liao et al., 2013; Yang et al., 2017b), one nucleobase (**136**) (Jing et al., 2015), two amides (**137**,**138**) (Liao et al., 2013; Wang et al., 2013), and one alkaloid (**139**) (Wang et al., 2013) were obtained from the aerial parts or whole plant of *P. capitatum*. It is possible that flazine (**139**) is produced through dehydration and dehydrogenation of 5-hydroxymethyl furfural (**8**) (Yu et al., 2008) and L-tryptophan (**135**) (Yang et al., 2017b).

Eight alkyl glycosides (**140–147**) (Yang et al., 2011, 2017a) were obtained from the whole plant of *P. capitatum*. Their alkyl groups are all *n*-butyls, which may be introduced because of n-butanol extraction. The sugar residues of seven alkyl glycosides (**140–146**) are glucosyl or fructosyl with a pyran or furan ring structure (Yang et al., 2017a).

Fifty-six kinds of volatile oils (**148–203**) (Gao et al., 2005; Wang et al., 2007) were identified from the whole plant of *P. capitatum*, including monoterpenes, sesquiterpenes, monocyclic and polycyclic aromatic hydrocarbons, and straight-chain aliphatic (less than 24 carbons) hydrocarbons, alcohols, aldehydes, ketones, acids, and esters.

In addition, water-soluble polysaccharides were isolated from water-extract of *P. capitatum*. Analysis, using GC and GC-MS after hydrolysis and derivatization, showed that their monosaccharide components include rhamnose, arabinose, xylose, glucose, and galactose, among which rabinose, glucose, and galactose were the major components (Wang et al., 2011).

3 Conclusions

To sum up, previous phytochemical studies on *P. capitatum* showed that types of phytochemical constituents of *P. capitatum* included aliphatic hydrocarbons, aliphatic alcohols, aliphatic ketones, aromatic aldehydes, aliphatic acids, glycerides, triterpenic acids, sterols, anthraquinones, chromones and their glycosides, flavonoids and their glycosides, phenols, phenolic acids and their esters, lignanoids, flavonolignans, phenolic glycosides, alcoholic glycosides, amino acids, nucleobases, amides, alkaloids, alkyl glycosides, volatile oils, and polysaccharides.

The majority of studies on *P. capitatum* focused on (1) pharmacological effects and their mechanism related to hypoglycemic, antimicrobial and antitumor activities, (2) extraction, separation and purification of single components, effective component groups or fractions, (3) development of content determination or quality control methods for raw materials or pharmaceutical preparations.

This review provides reference for further research and application of *P. capitatum* and related preparations.

Conflict of interest

The authors declare that they have no conflict of interest.

Authors contribuitions

Yang Yang: Conceptualization, Planning this manuscript, Funding acquisition. Yang Yang and Qian Hong: Data curation, Writing this manuscript, Preparing all figures and tables. Bin Zhu, Zhonghai Zhou and Jie Yang: Investigation, Searching the reported publications related to this review article. All authors have read and agreed to the published version of the manuscript.

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References

Chen, B. Q., Li, C. Q., Chang, X., & Kang, W. Y. (2010a). Inhibitory activity of *Polygonum capitatum* to α-glucosidase. *Chinese Journal of Experimental Traditional Medical Formulae*, 16(8), 151-153.

Chen, X. B., Liu, X. Y., Chen, G. Y., & Liu, M. G. (2011). Study on chemical constituents of *Polygonum capitatum*. *Journal of Anhui Agricultural Sciences*, 39(23), 14025-14026.

Chen, X. X., Zhang, L. Y., Wan, J. Z., Liang, B., & Xie, Y. (2010b). Simultaneous isolation and purification of gallic acid and brevifolincarboxylic acid from *Polygonum capitatum* by high-speed counter-current chromatography. *China Journal of Chinese Materia Medica*, 35(15), 1957-1960. PMid:20931845.

Editorial Committee of Chinese Academy of Sciences. (1998). *Flora of China* (Vol. 25, pp. 57-58). Beijing: Science Press.

Fu, J., Ma, J. Y., Zhang, X. F., Wang, Y., Feng, R., Chen, Y. C., Tan, X. S., Zhang, Y. Y., Sun, Y. P., Zhou, Y., Ma, C., He, C. Y., Zhao, Z. X., & Du, X. W. (2012). Identification of metabolites of FR429, a potential antitumor ellagitannin, transformed by rat intestinal bacteria *in vitro*, based on liquid chromatography-ion trap-time of flight mass spectrometry analysis. *Journal of Pharmaceutical and Biomedical Analysis*, 71(12), 162-167. http://dx.doi.org/10.1016/j.jpba.2012.07.028. PMid:22910108.

Gao, L. M., Wei, X. M., & Zheng, S. Z. (2001). A novel flavone from *Polygonum capitatum* Buch.-Ham. ex D. Don. *Indian Journal of Chemistry*, 40B(6), 533-535.

Gao, Y. Q., Dai, Z. Q., Liu, J. H., Zhao, D. G., & Liu, S. H. (2005). Determination of volatile constituents of Herba Polygoni Capitati. *Biotechnology*, 15(3), 55-56.

Hartwig, N., Ferreira, C. F. J., Colazzo, C. C., Kupski, L., & Badiale-Furlong, E. (2020). Dry fruit as source of fungal contaminants or functional compounds? *Food Science and Technology*, 40(1), 76-83. http://dx.doi.org/10.1590/fst.32118.

He, C. Y., Fu, J., Ma, J. Y., Feng, R., Tan, X. S., Huang, M., Shou, J. W., Zhao, Z. X., Li, X. Y., Zhang, X. F., Chen, Y. C., & Wang, Y. (2014). Biotransformation and *in vitro* metabolic profile of bioactive extracts from a traditional Miao-nationality herbal medicine, *Polygonum capitatum. Molecules*, 19(7), 10291-10308. http://dx.doi.org/10.3390/molecules190710291. PMid:25033057.

Huang, G. H., Gao, Y., Wu, Z. J., Yang, Y., Huang, D. D., Chen, W. S., & Sun, L. N. (2015). Chemical constituents from *Polygonum capitatum* Buch-Ham. ex D. Don. *Biochemical Systematics and Ecology*, 59, 8-11. http://dx.doi.org/10.1016/j.bse.2014.12.012.

Huang, W. Y., Cai, Y. Z., Xing, J., Corke, H., & Sun, M. (2008). Comparative analysis of bioactivities of four *Polygonum* species. *Planta Medica*, 74(1), 43-49. http://dx.doi.org/10.1055/s-2007-993759. PMid:18067063.

Huang, Y., Zhou, Z. Y., Yang, W., Gong, Z. P., Li, Y. T., Chen, S. Y., Wang, Y. L., Wang, A. M., Lan, Y. Y., Liu, T., & Zheng, L. (2019). Comparative pharmacokinetics of gallic acid, protocatechuic acid, and quercitrin in normal and pyelonephritis rats after oral administration of a *Polygonum capitatum* extract. *Molecules*, 24(21), 3873. http://dx.doi.org/10.3390/molecules24213873. PMid:31717895.

Jing, W. G., Zhao, Y., Zhang, K. X., Zhang, J., & Liu, A. (2015). Study on the chemical constituents from aqueous extract of *Polygonum capitatum* Buch.-Ham.ex D. Don. *Lishizhen Medicine and Materia Medica Research*, 26(1), 47-50.

Li, X., Yu, M., Meng, D. L., Li, Z. L., & Zhang, L. Y. (2007). A new chromone glycoside from *Polygonum capitatum*. *Fitoterapia*, 78(7-8), 506-509. http://dx.doi.org/10.1016/j.fitote.2007.05.003. PMid:17659848.

Li, Y. J., Luo, H. F., Wang, Y. L., Sheng, W. Y., & Hu, C. Q. (2000). Studies on the chemical constituents of flavonoids from *Polygonum capitatum. Chinese Pharmaceutical Journal*, 35(5), 300-302.

Liao, S. G., Zhang, L. J., Sun, F., Wang, Z., He, X., Wang, A. M., Li, Y. J., Huang, Y., Lan, Y. Y., Zhang, B. L., & Wang, Y. L. (2013). Identification and characterisation of phenolics in *Polygonum capitatum* by ultrahigh-performance liquid chromatography with photodiode array detection and tandem mass spectrometry. *Phytochemical Analysis*, 24(6), 556-568. http://dx.doi.org/10.1002/pca.2432. PMid:24154994.

Liao, S. G., Zhang, L. J., Sun, F., Zhang, J. J., Chen, A. Y., Lan, Y. Y., Li, Y. J., Wang, A. M., He, X., Xiong, Y., Dong, L., Chen, X. J., Li, Y. T., Zuo, L., & Wang, Y. L. (2011). Antibacterial and anti-inflammatory effects of extracts and fractions from *Polygonum capitatum. Journal of Ethnopharmacology*, 134(3), 1006-1009. http://dx.doi.org/10.1016/j.jep.2011.01.050. PMid:21296143.

Liao, S. G., Zhang, L. J., Wang, Z., Sun, F., Li, Y. J., Wang, A. M., Huang, Y., Lan, Y. Y., & Wang, Y. L. (2012). Electrospray ionization and collision-induced dissociation tandem mass spectrometric discrimination of polyphenolic glycosides: exact acylation site determination of the O-acylated monosaccharide residues. *Rapid Communications in Mass Spectrometry*, 26(21), 2483-2492. http://dx.doi.org/10.1002/rcm.6366. PMid:23008065.

Liu, M., Luo, C. L., Zhang, Y. P., & Qiu, D. W. (2007). Studies on analgesia, antiinflammatory and diuresis effect of *Polygonum capitatum* and *Toddalia asiatica. Guizhou Medical Journal*, 31(4), 370-371.

Liu, Z. J., Qi, J., Zhu, D. N., & Yu, B. Y. (2008). Chemical constituents from *Polygonum capitatum* and their antioxidation activities *in vitro. Journal of Chinese Medicinal Materials*, 31(7), 995-998. PMid:18973013.

Ma, J. Y., Zhou, X. L., Fu, J., Hu, T., Or, P. M. Y., Feng, R., He, C. Y., Chen, W. J., Zhang, X. F., Chen, Y. C., Wang, Y., & Yeung, J. H. K. (2014). Metabolite profiling analysis of FR429, an ellagitannin purified from *Polygonum capitatum*, in rat and human liver microsomes, cytosol and rat primary hepatocytes *in vitro. Chemico-Biological Interactions*, 220(220), 33-40. http://dx.doi.org/10.1016/j.cbi.2014.06.002. PMid:24928742.

Nanjing University of Traditional Chinese Medicine. (2006). *Dictionary of Chinese herbal medicine*. (2nd ed., p. 850). Shanghai: Shanghai Science and Technology Press.

National Pharmacopoeia Committee. (2020). *Pharmacopoeia of the people's republic of China* (Part 1, p. 1454). Beijing: China Medical Science Press.

Pharmaceutical Administration of Guizhou Province. (2003). *Chinese crude drug and ethnic drug quality standard of guizhou province* (1st ed., p. 147). Guiyang: Guizhou Science and Technology Press.

Ren, G. Y., Chang, F. G., Lu, S. L., Zhong, H. L., & Zhang, G. L. (1995). Pharmacological studies of *Polygonum capitatum* Buch.-Ham. ex D. Don. *China Journal of Chinese Materia Medica*, 20(2), 107-109. PMid:7779271.

Syabana, M. A., Yuliana, N. D., Batubara, I., & Fardiaz, D. (2021). Antidiabetic activity screening and nmr profile of vegetable and spices commonly consumed in Indonesia. *Food Science and Technology*, 41(Suppl. 1), 254-264. http://dx.doi.org/10.1590/fst.14120.

Wabaidur, S. M., Obbed, M. S., Alothman, Z. A., Alfaris, N. A., Badjah-Hadj-Ahmed, A. Y., Siddiqui, M. R., Altamimi, J. Z., & Aldayel, T. S. (2020). Total phenolic acids and flavonoid contents determination in Yemeni honey of various floral sources: Folin-Ciocalteu and spectrophotometric approach. *Food Science and Technology*, 40(Suppl. 2), 647-652. http://dx.doi.org/10.1590/fst.33119.

Wang, H. P., Cao, F., & Yang, X. W. (2013). Chemical constituents in aerial parts of *Polygonum capitatum. Chinese Traditional and Herbal Drugs*, 44(1), 24-30.

Wang, X. P., Wan, D. G., & Wu, H. M. (2007). GC-MS analysis of volatile oil from Sichuan wild and cultivated *Polygonum capitatum. Journal of Guiyang College of Traditional Chinese Medicine*, 29(5), 61-62.

Wang, Y., Ma, J. Y., Chow, S. C., Li, C. H., Xiao, Z. G., Feng, R., Fu, J., & Chen, Y. C. (2014). A potential antitumor ellagitannin, davidiin, inhibited hepatocellular tumor growth by targeting EZH2. *Tumour Biology*, 35(1), 205-212. http://dx.doi.org/10.1007/s13277-013-1025-3. PMid:23897557.

Wang, Z. Q., & Jiang, X. J. (2018). Flavonoid-rich extract of *Polygonum capitatum* attenuates high-fat diet-induced atherosclerosis development and inflammatory and oxidative stress in hyperlipidemia rats. *European Journal of Inflammation*, 20, 1-8. http://dx.doi.org/10.1177/2058739218772710.

Wang, Z., Wan, J. Z., Yao, B. Y., Zhang, L. Y., Li, M. L., & Xie, Y. (2011). Analysis of polysaccharide components from Herba Polygoni Capitati by gas chromatography and gas chromatography-mass spectrometry. *Traditional Chinese Drug Research and Clinical Pharmacology*, 22(4), 458-461.

Wu, N. J., & Wang, D. R. (1985). Study on the chemical constituents of *Polygonum capitatum. Chinese Traditional and Herbal Drugs*, 16(4), 5-6.

Yan, X. L., Li, C. Q., Liu, Y. X., Chang, X., & Kang, W. Y. (2010). Antioxidant activity of *Polygonum capitatum. China Pharmacy*, 2(39), 3659-3661.

Yang, B. B., Feng, R., Wang, W. C., Zhang, L. Y., Ye, X. M., Wang, Y., & Wang, M. Z. (2008). Quantitative analysis of three active constituents in Miao regional herb, *Polygonum capitatum* by HPLC/DAD/MS. *Chinese Journal of Pharmaceutical Analysis*, 28(11), 1793-1796.

Yang, W., Hou, J., Lu, Y., Chen, P. C., Liao, S. G., & Huang, Y. (2015a). Intestinal absorption kinetics of *Polygonum capitatum* extract in rats. *China Journal of Chinese Materia Medica*, 40(21), 4281-4287. PMid:27071271.

Yang, Y., Cai, F., Yang, Q., Yang, Y. B., Sun, L. N., & Chen, W. S. (2009). Study on chemical constituents of *Polygonum capitatum* Buch.-Ham. ex D. Don (I). *Academic Journal of Second Military Medical University*, 30(8), 937-940.

Yang, Y., Wang, Z. P., Gao, S. H., & Wu, Z. J. (2017a). Alkyl glycosides from n-butanol fraction of *Polygonum capitatum* Herbs. *Journal of Chinese Medicinal Materials*, 40(8), 1846-1848.

Yang, Y., Wu, Z. J., & Chen, W. S. (2015b). Chemical constituents from *Polygonum capitatum. Chemistry of Natural Compounds*, 51(2), 332-335. http://dx.doi.org/10.1007/s10600-015-1274-z.

Yang, Y., Yang, Y. B., Lu, W. Q., Wu, Z. J., & Chen, W. S. (2017b). A new hydroxyjasmonic acid derivative from *Polygonum capitatum. Chemistry of Natural Compounds*, 53(3), 417-421. http://dx.doi.org/10.1007/s10600-017-2012-5.

Yang, Y., Yang, Y. B., Zhu, B., Wu, Z. J., & Chen, W. S. (2011). Chemical constituents of *Polygonum capitatum* II. *Chinese Journal of Experimental Traditional Medical Formulae*, 17(23), 92-94.

Yao, Y. G., Zhang, L. Y., Xie, L. M., Zhou, Y., Wang, J. R., Jiang, Z. H., Tang, J. W., Feng, T. T., & Xue, X. Y. (2018). Spectrum-effect relationship of antibacterial effect of different polar part of *Polygonum capitatum. Chinese Journal of Experimental Traditional Medical Formulae*, 24(1), 20-25.

Ye, Q. Z., Huan, G. H., Huang, D. D., Lv, S. S., Wu, Z. J., & Sun, L. N. (2017). Studies on lignans of *Polygonum capitatum* and their hypoglycemic activity. *Journal of Chinese Medicinal Materials*, 40(1), 107-110.

Yu, M., Li, Z. L., Li, N., & Li, X. (2008). Chemical constituents of the aerial parts of *Polygonum capitatum. Journal of Shenyang Pharmaceutical University*, 25(8), 633-635.

Zhang, K. X., Wang, Y. S., Jing, W. G., Zhang, J., & Liu, A. (2013a). Improved quality control method for prescriptions of *Polygonum capitatum* through simultaneous determination of nine major constituents by HPLC coupled with triple quadruple mass spectrometry. *Molecules*, 18(10), 11824-11835. http://dx.doi.org/10.3390/molecules181011824. PMid:24071988.

Zhang, K. X., Zhang, J., Wei, S. H., Jing, W. G., Wang, Y. S., & Liu, A. (2013b). Development and validation of HPLC coupled with triple quadrupole MS for the simultaneous determination of six phenolic acids, six flavonoids, and a lignan in *Polygonum capitatum. Journal of Separation Science*, 36(15), 2407-2413. http://dx.doi.org/10.1002/jssc.201300291. PMid:23720387.

Zhang, L. J., Liao, S. G., Zhan, Z. H., Chen, X. J., & Lan, Y. Y. (2010). Studies on the chemical constituents of phenolic acids of Polygonum capitatum. *Lishizhen Medicine and Materia Medica Research*, 21(8), 1946-1947.

Zhang, L. J., Wang, Y. L., Wang, Z., Li, Y. J., Huang, Y., Long, Q. D., & Liao, S. G. (2012). Study on the chemical constituents of the active fraction of *Polygonum capitatum. Journal of Chinese Medicinal Materials*, 35(9), 1425-1428. PMid:23451496.

Zhang, S., Mo, F., Luo, Z. X., Huang, J., Sun, C. Q., & Zhang, R. (2015). Flavonoid glycosides of *Polygonum capitatum* protect against inflammation associated with *Helicobacter pylori* infection. *PLoS One*, 10(5), e0126584. http://dx.doi.org/10.1371/journal.pone.0126584. PMid:25993258.

Zhao, H. X., Bai, H., Li, W., & Wang, Y. S. (2010). Study on lignans of *Polygonum capitatum. Journal of Chinese Medicinal Materials*, 33(9), 1409-1411. PMid:21243770.

Zhao, H. X., Bai, H., Li, W., Wang, Y. S., Liu, Y. J., & Liu, A. Q. (2011). Chemical constituents from *Polygonum capitatum. Natural Product Research and Development*, 23(2), 262-266.

Zhao, Y. K., Huang, D. D., Wang, X., Jing, S. G., & Sun, L. N. (2020). Quality standard for *Polygonum capitatum. Chinese Traditional Patent Medicine*, 42(2), 408-415.

Zheng, L., Lu, Y., Cao, X., Huang, Y., Liu, Y., Tang, L., Liao, S. G., Wang, A. M., Li, Y. J., Lan, Y. Y., & Wang, Y. L. (2014). Evaluation of the impact of *Polygonum capitatum*, a traditional Chinese herbal medicine, on rat hepatic cytochrome P450 enzymes by using a cocktail of probe drugs. *Journal of Ethnopharmacology*, 158, 276-282. http://dx.doi.org/10.1016/j.jep.2014.10.031. PMid:25446640.

Zhong, Y. C. (2001). *Polygonum capitatum*: an ideal wild cover plant. *Plants*, (6), 16-17.

Zhou, W., Zhang, L. Y., Xie, L. M., Qiu, L. F., Wang, J. R., Ma, S. B., Jiang, Z. H., & Tang, J. W. (2017). Analysis of alcohol extract and water extract of *Polygonum capitatum* by UPLC-Q-TOF-MS. *China Journal of Chinese Materia Medica*, 42(18), 3557-3563. PMid:29218942.