

# 植物三七中皂苷类化学成分的研究进展<sup>①</sup>

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**摘要** 三七总皂苷是中药三七[*Notoginseng Radix et Rhizoma*]的主要活性成分,具有止血与活血、改善心脑血管系统、抗炎、抗肿瘤和提高机体免疫力等药理作用,三七总皂苷的研究得到了广泛关注,成为中药研究中的重要领域,研究十分活跃.本文结合作者的工作基础及国内外相关文献,对三七中的皂苷类化学成分按照结构类型、皂苷来源进行了系统归纳,综述了三七活性成分在止血、活血、抗炎、抗肿瘤、提高免疫力等方面的药理作用,以期对三七中皂苷类成分的进一步研究提供参考.

**关键词** 三七;化学成分;皂苷类;三七皂苷;人参皂苷

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## 0 引言

中药三七[*Notoginseng Radix et Rhizoma*]为植物三七[*Panax notoginseng* (Burk.) F. H. Chen]的干燥根和根茎.一般秋季花开前采挖,洗净,分开主根、支根及根茎后干燥而得.三七具有散瘀止血,消肿定痛等功效,主要用于治疗咯血、衄血、吐血、便血、崩漏、外伤出血及跌扑肿痛等症<sup>[1]</sup>.三七的应用在我国具有悠久的历史,明代巨著《本草纲目》就对三七有详细的描述.

三七的药用价值与其本身所含有的化学成分是密不可分的,目前为止,从三七中分离得到的化学成分主要有皂苷类、黄酮类、糖类、多醇类、聚炔醇类、挥发油类、氨基酸类及有机酸类等,其中皂苷类为三七的主要化学成分,同时也是公认的主要活性成分.以三七总皂苷(Panax Notoginseng Saponins, PNS)为原料药的中药制剂,如血塞通注射液、三七总皂苷片、三七总皂苷胶囊等,已经成为目前中药制剂中年销售额最大的品种之一.从三七中发现的皂苷类成分均为达玛烷型的四环三萜化合物,在三七中至今尚未发现齐墩果酸型皂苷.达玛烷型皂苷根据分子母核结构的C-6位是否存在羟基取代,又可将三七皂苷分为原人参二醇型(protoanaxadiol, PPD)和原人参三醇型(protoanaxatriol, PPT).对于三七中皂苷类化学成分的研究时间跨度较大,种类区分繁琐.为方便比较与人参、越南参等药材在皂苷成分方面的差异,本文按照结构类型、皂苷来源等,将三七中皂苷类化学成分分为原人参二醇型皂苷、原人参三醇型皂苷和特殊结构类型皂苷,以期对三七中皂苷类成分的进一步研究提供参考.

## 1 原人参二醇型皂苷(PPDs)

原人参二醇型皂苷是三七总皂苷的主要组成部分,主要包括三七皂苷R<sub>4</sub>、Fa、Fc(表1),人参皂苷Rb<sub>1</sub>、Rb<sub>2</sub>(表2)以及绞股蓝皂苷XVⅡ、Ⅸ、XV和西洋参皂苷Ⅳ(表3)等.根据其C-20构型不同,分为20(S)-原人参二醇型[20(S)-protoanaxadiol]皂苷和20(R)-原人参二醇型[20(R)-protoanaxadiol]皂苷.

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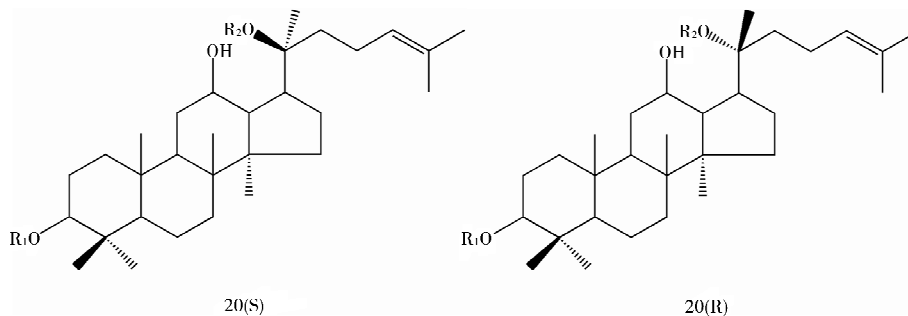


图 1 20(S)-原人参二醇型皂苷和 20(R)-原人参二醇型皂苷的化学结构

表 1 原人参二醇型三七皂苷

Notoginsenosides	R <sub>1</sub>	R <sub>2</sub>	C <sub>20</sub>
Notoginsenoside R <sub>4</sub> <sup>[2]</sup>	-glc (2-1) glc	-glc (6-1) glc (6-1) xyl	S
Notoginsenoside Fa <sup>[3]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) glc	S
Notoginsenoside Fc <sup>[3]</sup>	-glc (2-1) glc(2-1) xyl	-glc (6-1) xyl	S
Notoginsenoside Fe <sup>[3]</sup>	-glc	-glc (6-1) ara(p)	S
Notoginsenoside D <sup>[4]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) glc (6-1) xyl	S
Notoginsenoside K <sup>[5]</sup>	-glc (6-1) glc	-glc	S
Notoginsenoside L <sup>[5]</sup>	-glc(2-1) xyl	-glc (6-1) glc	S
Notoginsenoside L* <sup>[6]</sup>	-glc	-glc (2-1) ara(p)	S
Notoginsenoside O <sup>[7]</sup>	-glc	-glc (6-1) xyl (3-1) xyl	S
Notoginsenoside P <sup>[8]</sup>	-glc	-glc (6-1) xyl (4-1) xyl	S
Notoginsenoside Q <sup>[7]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) xyl (4-1) xyl	S
Notoginsenoside S <sup>[7]</sup>	-glc(2-1) glc (2-1) xyl	-glc (6-1) ara (5-1) xyl	S
Notoginsenoside T <sup>[7]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) glc (3-1) xyl	S
Notoginsenoside FP <sub>2</sub> <sup>[9]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) ara(p)	S
Notoginsenoside Ft <sub>1</sub> <sup>[9]</sup>	-glc (2-1) glc (2-1) xyl	II	R
Notoginsenoside ST-4 <sup>[10]</sup>	-glc (2-1) glc (2-1) xyl	H	S
Notoginsenoside FZ <sup>[11]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) ara(p)	R
Notoginsenoside Fh <sub>1</sub> <sup>[47]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) ara (4-1) xyl	S

注: glc; β-D-glucopyranosyl; xyl; β-D-xylopyranosyl; ara(p); α-D-arabinopyranosyl.

表 2 原人参二醇型人参皂苷

Ginsenosides	R <sub>1</sub>	R <sub>2</sub>	C <sub>20</sub>
Ginsenoside Ra <sub>3</sub> <sup>[4]</sup>	-glc (2-1) glc	-glc (6-1) glc (3-1) xyl	S
Ginsenoside Rb <sub>1</sub> <sup>[12]</sup>	-glc (2-1) glc	-glc (6-1) glc	S
Malonyl-ginsenoside Rb <sub>1</sub> <sup>[13]</sup>	-glc (2-1) glc (6) mal	-glc (6-1) glc	S
Ginsenoside Rb <sub>2</sub> <sup>[14]</sup>	-glc (2-1) glc	-glc (6-1) xyl	S
Ginsenoside Rc <sup>[15]</sup>	-glc (2-1) glc	-glc (6-1) ara(p)	S
Ginsenoside Rd <sup>[16]</sup>	-glc (2-1) glc	-glc	S
Malonyl-ginsenoside Rd <sup>[17]</sup>	-glc (2-1) glc (6) mal	-glc	S
20(S)-Ginsenoside Rg <sub>3</sub> <sup>[26]</sup>	-glc (2-1) glc	II	S
20(R)-Ginsenoside Rg <sub>3</sub> <sup>[10]</sup>	-glc (2-1) glc	H	R
6''-O-acetylginsenoside Rg <sub>3</sub> <sup>[17]</sup>	-glc (2-1) glc (6) Ac	H	R
Ginsenoside F <sub>2</sub> <sup>[15]</sup>	-glc	-glc	S
20(S)-Ginsenoside Rh <sub>2</sub> <sup>[18]</sup>	-glc	H	S
Ginsenoside CK <sup>[19]</sup>	H	-glc	S
Ginsenoside Mc <sup>[20]</sup>	II	-glc (6-1) ara(p)	S

注: glc; β-D-glucopyranosyl; xyl; β-D-xylopyranosyl; Ac; acetyl; ara(p); α-D-arabinopyranosyl; mal; malonyl.

表 3 原人参二醇型其它皂苷

Saponins	R <sub>1</sub>	R <sub>2</sub>	C <sub>20</sub>
Gypenoside XV II <sup>[21]</sup>	-glc	-glc (6-1) glc	S
Gypenoside IX <sup>[22]</sup>	-glc	-glc (6-1) xyl	S
Gypenoside XV <sup>[23]</sup>	-glc (2-1) xyl	-glc (6-1) xyl	S
Gypenoside VIII <sup>[24]</sup>	H	-glc (6-1) xyl	S
Quinquenoside IV <sup>[13]</sup>	-glc (2-1) glc (6) Ac	-glc (6-1) glc	S

注: glc:  $\beta$ -D-glucopyranosyl; xyl:  $\beta$ -D-xylopyranosyl; Ac: acetyl.

## 2 原人参三醇型皂苷(PPDs)

原人参三醇型皂苷也是三七总皂苷的重要成分,主要包括三七皂苷 R<sub>1</sub>、R<sub>2</sub>(表 4),人参皂苷 Rg<sub>1</sub>、Rg<sub>2</sub>(表 5)以及竹节参皂苷和韩国人参皂苷(表 6)等. 根据其 C-20 构型不同,分为 20(S)-原人参三醇型[20(S)-protopanaxadiol]皂苷和 20(R)-原人参三醇型[20(R)-protopanaxadiol]皂苷.

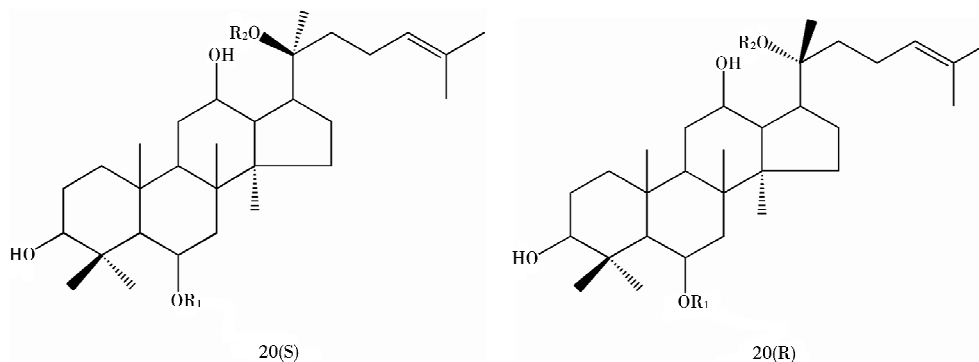


图 2 20(S)-原人参三醇型皂苷和 20(R)-原人参三醇型皂苷的化学结构

表 4 原人参三醇型三七皂苷

Notoginsenosides	R <sub>1</sub>	R <sub>2</sub>	C <sub>20</sub>
Notoginsenoside R <sub>1</sub> <sup>[25]</sup>	-glc (2-1) xyl	-glc	S
Notoginsenoside R <sub>2</sub> <sup>[25]</sup>	-glc (2-1) xyl	H	S
Notoginsenoside R <sub>3</sub> <sup>[2]</sup>	-glc	-glc (6-1) glc	S
Notoginsenoside R <sub>6</sub> <sup>[2]</sup>	-glc	-glc (6-1) glc*	S
Notoginsenoside M <sup>[7]</sup>	-glc (6-1) glc*	-glc	-S
Notoginsenoside N <sup>[7]</sup>	-glc (4-1) glc*	-glc	-S
Notoginsenoside Rt <sup>[27]</sup>	-glc (6) Ac	-glc	S
Notoginsenoside T <sub>3</sub> <sup>[28]</sup>	-glc	-Et	S
Notoginsenoside FP <sub>1</sub> <sup>[37]</sup>	-glc	-glc (6-1) ara(p)	S
Notoginsenoside N <sup>[7]</sup>	-glc (4-1) glc*	-glc	-S
Yesaninoside D <sup>[4]</sup>	-glc (6-1) Ac	-glc	S
Yesaninoside U <sup>[29]</sup>	H	-glc (6-1) glc	S
Notoginsenoside Rw <sub>1</sub> <sup>[30]</sup>	-xyl	-glc (6-1) xyl	S
Notoginsenoside Fh <sub>7</sub> <sup>[57]</sup>	-glc (2-1) glc	-glc (6-1) glc	S

注: glc:  $\beta$ -D-glucopyranosyl; glc\*:  $\alpha$ -D-glucopyranosyl; Ac: acetyl; ara(p):  $\alpha$ -D-arabinopyranosyl.

## 3 特殊类型皂苷

三七总皂苷中还有一类母核或者侧链发生变化的四环三萜皂苷,种类繁多,占三七总皂苷数量的半数以上. 这类皂苷大多是在药材加工、炮制、提取过程中,如蒸制、酸水解而产生的次级皂苷,近年来最新发现

的皂苷也以这类化合物为主。主要包括三七皂苷  $R_7$ 、 $R_8$ (图 3、表 7), 人参皂苷  $R_{g_6}$ 、 $R_{g_5}$ (图 4、表 8) 以及绞股蓝皂苷、三七花皂苷和人参花皂苷(图 5、表 9) 等。

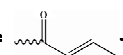
表 5 原人参三醇型人参皂苷

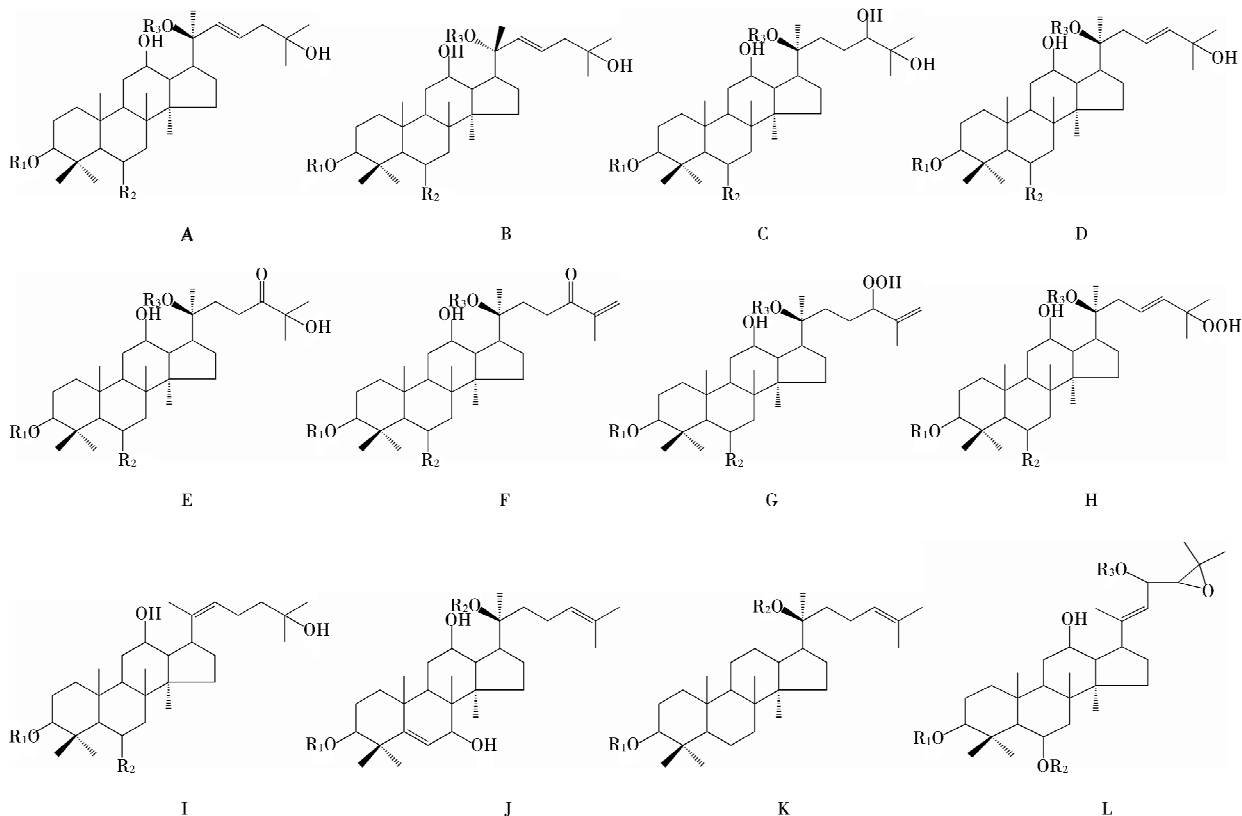
Ginsenosides	$R_1$	$R_2$	$C_{20}$
Ginsenoside Re <sup>[16]</sup>	-glc (2-1) rha	-glc	S
20-O-glucoginsenoside Rf <sup>[21]</sup>	-glc (2-1) glc	-glc	S
Ginsenoside $R_{g_1}$ <sup>[16]</sup>	-glc	-glc	S
Malonyl-ginsenoside $R_{g_1}$ <sup>[31]</sup>	-glc (6) mal	-glc	S
Ginsenoside $R_{g_2}$ <sup>[25]</sup>	-glc (2-1) rha	H	S
20(S)-Ginsenoside Rh <sub>1</sub> <sup>[25]</sup>	-glc	H	S
20(R)-Ginsenoside Rh <sub>1</sub> <sup>[10]</sup>	-glc	II	R
Ginsenoside F <sub>1</sub> <sup>[4]</sup>	II	-glc	S

注: glc;  $\beta$ -D-glucopyranosyl; rha;  $\alpha$ -L-rhamnopyranosyl; mal; malonyl.

表 6 原人参三醇型其它皂苷

Saponins	$R_1$	$R_2$	$C_{20}$
Chikusetsu saponin L <sub>5</sub> <sup>[18]</sup>	H	-glc (6-1) ara (4-1) xyl	S
Koryoginsenoside R <sub>1</sub> <sup>[32]</sup>	-glc (6-1) Bu	-glc	S
Pseudoginsenoside RT <sub>3</sub> <sup>[33]</sup>	-xyl	-glc	S
Saponin 10 <sup>[38]</sup>	-glc	-xyl	S
Saponin 1 <sup>[11]</sup>	H	-glc (6-1) glc (6-1) xyl	S
Saponin 2 <sup>[14]</sup>	-xyl (6-1) un	-	S
Saponin 3 <sup>[11]</sup>	-xyl (6-1) xyl	H	S

注: glc;  $\beta$ -D-glucopyranosyl; xyl;  $\beta$ -D-xylopyranosyl; ara;  $\alpha$ -D-arabifuranosyl; Bu; n-butyl; un; .



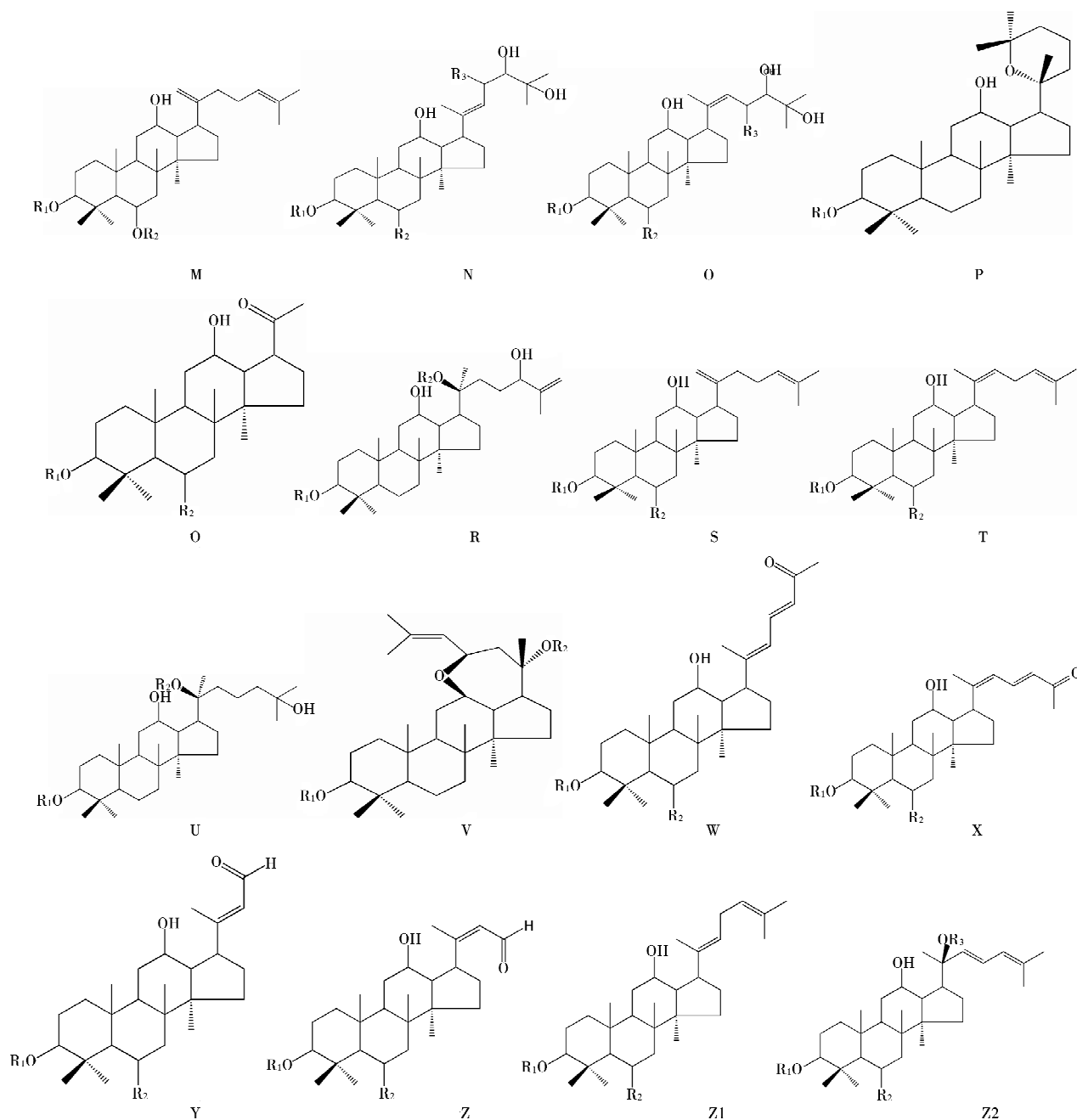


图 3 特殊类型三七皂苷母核结构

表 7 特殊类型三七皂苷

Notoginsenosides	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	types
Notoginsenoside R <sub>7</sub> <sup>[34]</sup>	-glc	-	-	P
Notoginsenoside R <sub>8</sub> <sup>[35]</sup>	H	-O-glc	H	A
Notoginsenoside R <sub>9</sub> <sup>[35]</sup>	H	-O-glc	H	B
Notoginsenoside R <sub>10</sub> <sup>[36]</sup>	II	-O-glc	-	Q
Notoginsenoside A <sup>[4]</sup>	-glc (2-1) glc	H	-glc (6-1) glc	D
Notoginsenoside B <sup>[4]</sup>	-glc (2-1) glc	H	-glc (6-1) glc	F
Notoginsenoside Fh <sub>2</sub> <sup>[47]</sup>	-glc (2-1) glc (2-1) xyl	II	-glc (6-1) glc	F
Notoginsenoside C <sup>[4]</sup>	-glc (2-1) glc	H	-glc (6-1) glc	G
Notoginsenoside E <sup>[4]</sup>	-glc (2-1) glc	H	-glc	D
Notoginsenoside H <sup>[5]</sup>	II	-O-glc (2-1) xyl	-glc	D

续表 7 特殊类型三七皂苷

Notoginsenosides	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	types
Yesanchinoside II <sup>[43]</sup>	II	-O-glc (2-1) glc	-glc (2-1) xyl	D
Notoginsenoside J <sup>[8]</sup>	H	-O-glc	-glc	C
Notoginsenoside M <sup>*[6]</sup>	H	-O-glc	-glc	D
Notoginsenoside T <sub>4</sub> <sup>[28]</sup>	H	-O-glc	H	C
Notoginsenoside B <sub>1</sub> <sup>[38]</sup>	H	-O-glc	-	I
Notoginsenoside G <sup>[5]</sup>	-glc (2-1) glc	-glc	-	J
Notoginsenoside I <sup>[8]</sup>	-glc (2-1) glc	-glc (6-1) glc	-	K
Notoginsenoside T <sub>1</sub> <sup>[28]</sup>	II	-glc	II	L
Notoginsenoside T <sub>2</sub> <sup>[28]</sup>	II	-glc	-Me	L
Notoginsenoside T <sub>5</sub> <sup>[28]</sup>	H	-glc (3-1) xyl	-	M
Notoginsenoside ST-1 <sup>[17]</sup>	H	-O-glc	H	N
Notoginsenoside ST-2 <sup>[17]</sup>	-glc (2-1) glc	H	-O-Me	N
Notoginsenoside ST-3 <sup>[17]</sup>	-glc (2-1) glc	H	-O-Me	O
Notoginsenoside ST-5 <sup>[17]</sup>	-glc (2-1) glc (2-1) xyl	H	H	H
Notoginsenoside ST-6 <sup>[46]</sup>	H	-O-glc	-	W
Notoginsenoside ST-7 <sup>[46]</sup>	II	-O-glc	-	X
Notoginsenoside ST-8 <sup>[46]</sup>	II	-O-glc	-	Y
Notoginsenoside ST-9 <sup>[46]</sup>	H	-O-glc	-	Z
Notoginsenoside ST-10 <sup>[46]</sup>	-O-glc	H	-	Y
Notoginsenoside ST-11 <sup>[46]</sup>	-xyl	H	-	Z1
Notoginsenoside ST-12 <sup>[46]</sup>	-xyl	H	-	S
Notoginsenoside ST-14 <sup>[46]</sup>	H	-O-glc	H	Z2
Notoginsenoside SFt <sub>1</sub> <sup>[39]</sup>	-glc	II	-	R
Notoginsenoside Fh <sub>3</sub> <sup>[47]</sup>	-glc (2-1) glc (2-1) xyl	H	-glc (2-1) xyl	R
Notoginsenoside Fh <sub>4</sub> <sup>[47]</sup>	-glc (2-1) glc (2-1) xyl	II	-glc (6-1) glc	R
Notoginsenoside Fh <sub>5</sub> <sup>[47]</sup>	-glc (2-1) glc (2-1) xyl	II	-glc (6-1) glc	D
Notoginsenoside SFt <sub>2</sub> <sup>[39]</sup>	-glc	-	II	C
Notoginsenoside SFt <sub>3</sub> <sup>[39]</sup>	-glc (2-1) glc (2-1) xyl	-	-	S
Notoginsenoside SFt <sub>4</sub> <sup>[39]</sup>	-glc (2-1) glc (2-1) xyl	-	-	T
Notoginsenoside Ft2 <sup>[9]</sup>	-glc (2-1) glc (2-1) xyl	H	-	U
Notoginsenoside Rw2 <sup>[30]</sup>	H	-O-glc (2-1) xyl	H	A
Notoginsenoside Ft3 <sup>[9]</sup>	-glc (2-1) glc (2-1) xyl	H	-	R
Notoginsenoside LX <sup>[11]</sup>	-glc	-glc (6-1) ara(f)	-	V
Notoginsenoside LY <sup>[11]</sup>	-glc	-glc (6-1) ara(f)	-	V
Notoginsenoside Ng <sub>3</sub> <sup>[48]</sup>	-glc (2-1) glc (2-1) xyl	-glc (6-1) glc	-	V
Epoxynotoginsenoside A <sup>[40]</sup>	-glc (2-1) glc	-glc (6-1) glc	-	V

注: glc:  $\beta$ -D-glucopyranosyl; xyl:  $\beta$ -D-xylopyranosyl; ara(f):  $\alpha$ -D-arabifuranosyl.

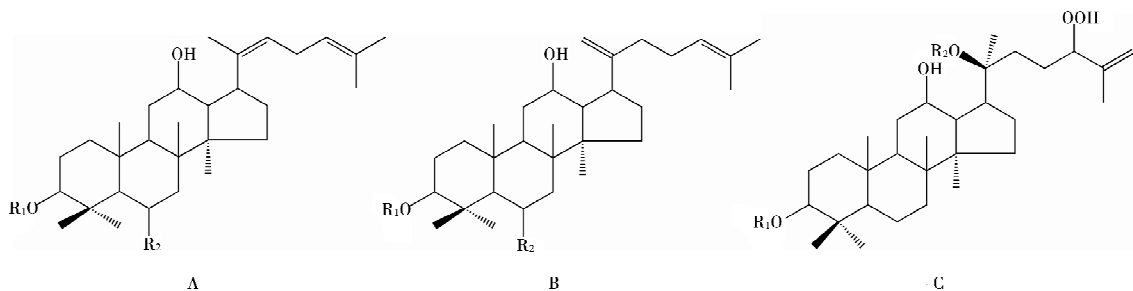


图 4 特殊类型人参皂苷母核结构

表 8 特殊类型人参皂苷

Ginsenosides	R <sub>1</sub>	R <sub>2</sub>	types
Ginsenoside Rk <sub>3</sub> <sup>[10]</sup>	H	-O-glc	B
Ginsenoside Rh <sub>4</sub> <sup>[10]</sup>	H	-O-glc	A
Ginsenoside Rk <sub>2</sub> <sup>[39]</sup>	-glc	H	B
Ginsenoside Rh <sub>3</sub> <sup>[39]</sup>	-glc	H	A
Ginsenoside Rk <sub>1</sub> <sup>[10]</sup>	-glc (2-1) glc	H	B
Ginsenoside Rg <sub>5</sub> <sup>[10]</sup>	-glc (2-1) glc	II	A
Ginsenoside II <sup>[41]</sup>	-glc (2-1) glc	II	C

注: glc;  $\beta$ -D-glucopyranosyl; rha;  $\alpha$ -L-rhamnopyranosyl.

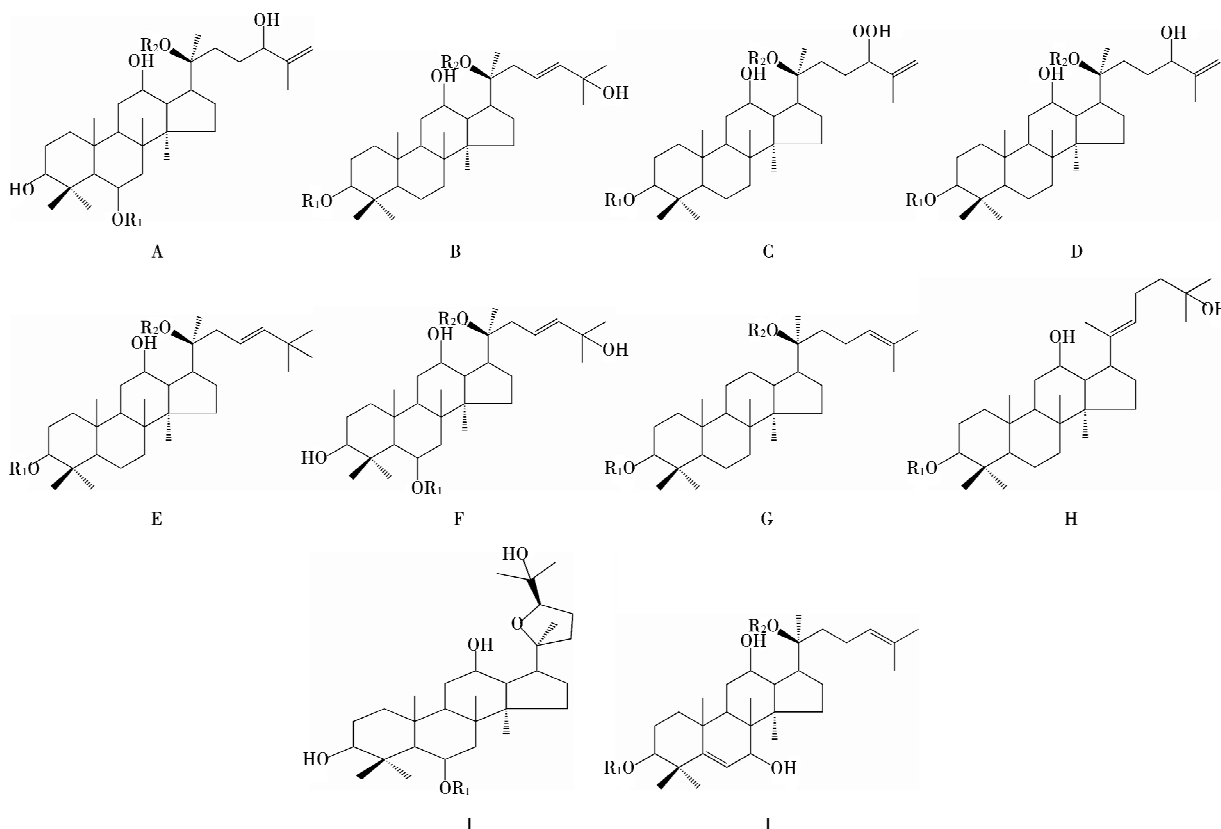


图 5 其它类型皂苷母核结构

## 4 药理作用

三七总皂苷(PNS)具有止血与活血、改善心脑血管系统、抗炎、抗肿瘤和提高机体免疫力等药理作用,是中药研究的重要领域,对中风偏瘫、动脉粥样硬化性血栓性脑梗塞、脑血栓、脑血管出血后遗症及视网膜中央静脉阻塞等等疾病的治疗具有重要作用。

### 4.1 止血与活血

三七具有止血(促进血液凝固)的作用,现代药理学研究表明,三七中的一种非构成蛋白质的氨基酸-田七氨酸(三七素)是主要的止血成分。目前认为田七氨酸是通过影响机体的凝血系统、血小板聚集和纤溶系统达到增强止血的作用,即激活内源性多种凝血因子,提高血浆中纤维蛋白原含量,促进血小板第一相和第二相的聚集,抑制纤维蛋白溶解、形成血栓来实现<sup>[44]</sup>。

三七具有双向调节作用,即有促进血液凝固,又具有活血(促进血块溶解)、抗血栓作用,三七总皂苷(PNS)为其主要的活血成分。苏雅等用三醇型皂苷(PTS)研究其对动物血小板功能及血栓形成的影响,结果表明,PNS能抑制血小板释放血栓素 A<sub>2</sub>、B<sub>2</sub> 等活性物质,产生抗血小板聚集作用。本课题组研究<sup>[45]</sup>发

现三七总皂苷中的 14 种皂苷单体对二磷酸腺苷(ADP)诱导的血小板聚集均表现出较好的抑制活性,且具有浓度依赖性.在同一浓度下,14 种皂苷单体抗 ADP 引发的血小板聚集活性大小顺序为  $Rg_5 > Rk_1 \sim Rg_6 > F_4 > Rg_3 > Rd \sim Re \sim Rb_3 \sim Rb_2 > Rk_3 > Rh_1 > Rb_1 > R_1 > Rg_1$ .

表 9 其它类型皂苷

Saponins	R <sub>1</sub>	R <sub>2</sub>	types
Notopanaxoside A <sup>[42]</sup>	-glc	H	A
Floranotoginsenoside A <sup>[45]</sup>	-glc (2-1) glc	-glc (6-1) ara (f)	B
Floranotoginsenoside B <sup>[45]</sup>	-glc (2-1) glc	-glc (6-1) xyl	C
Floranotoginsenoside C <sup>[45]</sup>	-glc (2-1) glc	-glc (6-1) ara (f)	C
Floranotoginsenoside D <sup>[45]</sup>	-glc (2-1) glc	-glc (6-1) ara (f)	D
Gypenoside LXIX <sup>[45]</sup>	-glc (2-1) glc	-glc (6-1) xyl	B
Gypenoside LXIX <sup>* [45]</sup>	-glc (2-1) glc	-glc (6-1) xyl	E
Floraginsenoside O <sup>[45]</sup>	-glc (2-1) glc	-glc (6-1) ara(f)	E
Gypenoside LXXI <sup>[45]</sup>	-glc (2-1) glc	-glc (6-1) xyl	A
Vina-ginsenosides R <sub>15</sub> <sup>[33]</sup>	-glc	-glc	F
Vina-ginsenosides R <sub>3</sub> <sup>[33]</sup>	-glc (2-1) glc	-glc	G
Saponin 6 <sup>[33]</sup>	-glc (2-1) glc	-	H
Pseudoginsenoside RT <sub>5</sub> <sup>[27]</sup>	-glc	-	I
Quinquenoside IV <sup>[18]</sup>	-glc (2-1) glc	-glc (6-1) glc	J

注:glc,β-D-glucopyranosyl; xyl,β-D-xylopyranosyl; ara(f),α-D-arabifuranosyl.

#### 4.2 改善心脑血管系统

心肌缺血再灌注损伤能够引起心肌细胞的凋亡.三七总皂苷(PNS)具有抗心肌缺血再灌注损伤的作用,主要通过抗氧化应激、阻滞钙离子超载、抑制中性粒细胞活化黏附、调节能量代谢、抑制细胞凋亡、调节血管内皮细胞功能等途径保护心肌,防止再灌注损伤<sup>[49]</sup>.

脑部组织缺血会导致脑能量耗竭,进而影响脑组织正常生理功能<sup>[50]</sup>.三七总皂苷(PNS)可延缓组织细胞内高能磷酸化合物的分解,改善由于组织缺血而造成的能量耗竭,对脑组织具有明显的保护作用.同时 PNS 对钙通道具有阻滞作用,可以在一定程度上改善脑组织损伤后神经细胞内钙超载的现象,对脑组织损伤具有一定的保护作用.

#### 4.3 抗炎

三七总皂苷影响炎性免疫反应的作用机制较为复杂,主要是通过调节细胞因子,黏附分子(AM),小分子信使物质以及抑制细胞信号转导途径来影响炎性免疫反应. PNS 对多种炎症疾病具有一定干预作用,影响炎症反应发生环节、炎性介质产生,在一些免疫炎症疾病的治疗上, PNS 可能发挥重要作用<sup>[51,52]</sup>.

#### 4.4 抗肿瘤

三七总皂苷的抗肿瘤作用主要是通过抗炎免疫反应、提高机体免疫力以及控制基因表达和抑制信号传导通路引起的细胞凋亡来实现<sup>[53]</sup>.三七总皂苷能够直接抑制肿瘤细胞增殖,还可促进肿瘤细胞凋亡、抑制肿瘤细胞转移等途径发挥抗肿瘤作用.同时具有作为钙离子慢通道阻滞剂的发展潜力,具有不同于传统的钙离子拮抗剂的逆转机制.

### 5 结语与展望

本文主要对三七中的皂苷类化学成分研究现状进行了概述,并归纳了三七主要活性物质的药理作用.三七中的皂苷类成分为三七的主要化学成分,同时也是公认的主要活性成分.经过近百年的努力,国内外学者从三七中分离、提取、鉴定了 120 余种皂苷类化合物,基本阐明了三七中皂苷类成分的化学结构.三七中皂苷类化学成分的研究时间跨度较大,种类区分繁琐,本文针对三七中皂苷类化学成分按照结构类型、

皂苷来源等方面进行了系统归纳,为三七中皂苷类成分的进一步研究提供了参考。

三七中皂苷种类繁多,其基本母核为原人参二醇和原人参三醇类结构,其主要差别在于这些皂苷的侧链、糖基种类、位置和连接方式不同,进而导致其药理活性也不尽相同。近年来研究发现,稀有人参皂苷(如人参皂苷 Rh<sub>2</sub>、Rg<sub>3</sub>、Rh<sub>1</sub>、CK 等)的药理活性更好,但是含量极低、来源受限、难于分离。目前研究学者主要是通过生物转化、化学降解、微波降解等方法特定的将原人参二醇和原人参三醇组皂苷的侧链糖基降解以制备稀有人参皂苷。因此,通过降解提取方法的研究,将三七中的皂苷成分进行定向转化为稀有人参皂苷将成为三七药用价值开发的重要方向。同时,三七的药用价值体现在三七中的一类化合物或多个化合物协同作用,不能仅仅从单一的化学成分的角度研究三七的药理作用。

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### Synthesis and Herbicidal Activity of 3-Acyl-4-Hydroxyquinolin-2-ones

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**Abstract** To discover new herbicidal lead compounds, a series of 3-acyl-4-hydroxyquinolin-2-one derivatives was synthesized. The structures of all target compounds were confirmed by <sup>1</sup>H NMR, <sup>13</sup>C NMR and HRMS spectral data and their herbicidal activities were firstly evaluated. The bioassay results indicated that some of 3-acyl-4-hydroxyquinolin-2-one derivatives displayed good herbicidal activity to *Brassica campestris*, and especially compound II-13 had good herbicidal activities against *Brassica campestris in vitro* with 84.1% inhibition at a dose of 10 μg/mL. Compound II-13 was identified as the most potent candidate with 94.1% and 90.6% post-emergence inhibition against *Brassica campestris* and *Amaranthus retroflexus* at a dose of 100 g/hm<sup>2</sup>, respectively, which is comparable with the commercial herbicide mesotrione. Furthermore, the structure-activity relationships (SARs) was studied and provided some useful information for improving herbicidal activity. The present work indicated that 3-acyl-4-hydroxyquinolin-2-one motif could be a potential lead structure for further development of novel herbicides.

**Key words** 3-acyl-4-hydroxyquinolin-2-ones; synthesis; herbicidal activity; lead compounds

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### Research progress of Chemical constituents of saponins in *Panax Notoginseng*

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**Abstract** Saponins as the main effective constituent of Sanqi, are widely used in the treatment of stroke hemiplegia, cerebral infarction, cerebral thrombosis, cerebral hemorrhage sequelae, and retinal vein occlusion etc. The investigation on notoginseng has become an active and hot topic in traditional Chinese drugs. A great deal of effort has been devoted to this field, and many remarkable results were achieved. Herein, combining with authors' researches and referring to the works from literatures, the research progress of chemical constituents of saponins in *Panax notoginseng* are systematically reviewed in this article based on the structure and source. Their pharmaceutical activities in hemostasis, promoting blood circulation, anti-inflammatory, antitumor, immunity enhancement effects were also presented with the aim of providing new reference for further study of saponins in sanqi in the future.

**Key words** Sanqi; chemical constituent; saponins; notoginsenoside; ginsenoside