气相色谱-三重四极杆质谱分析人参炮制品中的挥发性成分

王 微 郑 飞 葛 岩 乔梦丹 越 皓* 刘淑莹
（长春中医药大学，吉林省人参科学研究院 长春 130117）

摘 要 人参炮制的化学成分变化研究主要集中在皂苷和糖类，本文首次从挥发性成分角度阐释了人参不同炮制品的物质基础。利用气相色谱-质谱联用（GC-MS/MS）方法，对鲜参、生晒参和红参中挥发性成分及其衍生规律进行研究。采用TG-5SILMS非极性气相色谱柱，以He为载气，通过NIST MS Spectral Database对挥发性成分进行检测并鉴定。鲜参、生晒参、红参中分别检出30、33和34种挥发性成分，其中生晒参中（－）-斯巴醇含量为鲜参含量的31.98倍，辛醛等8种挥发性成分为鲜参中含量的3倍以上，红参中有环癸等10种挥发性成分为鲜参中含量的3倍以上。生晒参和红参中各有4种挥发性成分在鲜参中未检出。

关键词 气相色谱-三重四极杆质谱；鲜参；生晒参；红参；挥发性成分
中图分类号：O657 文献标识码：A 文章编号：1000-0518(2017)08-0965-06
DOI：10.11944/j.issn.1000-0518.2017.08.160481

人参是多年生五加科草本植物人参（*Panax Ginseng* C. A. Mey.）的干燥根和根茎，具有生津养血、安神益智和抑制肿瘤等功效[1]。人参中活性成分主要包括人参皂苷、人参多糖、氨基酸、挥发性成分等[2]，其中人参皂苷与人参糖类的研究较多[3-5]。人参挥发性成分气味独特，抗疲劳等功能性产品已上市。人参中的挥发性成分质量分数仅为0.1%～0.5%，但其消炎、镇咳、抗疲劳、使神经中枢兴奋等作用明显，还能够通过抑制癌细胞的核酸代谢、糖代谢达到抑制癌细胞生长的作用[6]，其中β-榄香烯在抗癌方面得到了较多的研究和关注[7-8]。人参有生晒参和红参等不同炮制品，功效不同，气味也不同，生晒参中炔醇类物质较蒸制过的炮制品中含量高，其对革兰阳性金黄色葡萄球菌、枯草芽孢杆菌、肺炎双球菌等抑菌作用更强[9]，同时其抗肿瘤和神经保护等活性更强[10-11]。气相色谱-质谱联用（GC-MS/MS）技术与NIST MS Spectral Database结合使用，常用作脂肪酸和挥发性成分的测定[12-13]。本研究采用水蒸气回流提取法结合气相色谱-三重四极杆质谱联用检测技术[14-15]，建立了GC-MS/MS测定人参挥发性成分的方法，应用于对鲜参、生晒参和红参中挥发性成分的比较，明确鲜参及其炮制品挥发性成分的组成，推断生晒参和红参中的挥发性成分衍生路径，为人参炮制机理的研究提供挥发性成分的化学数据。

1 实验部分

1.1 仪器和试剂、药材

TRACE 1310 GC-Triple Quadrupole MS型气相色谱串联质谱仪（美国Thermo Science公司）。

正己烷（色谱纯，TEDIA公司），蒸馏水（实验室自制）。鲜参（5年生）；生晒参（由同批次鲜参人参挖出洗净放置通风阴凉处阴干后的炮制品）；红参（由同批次鲜参经过清洗、分选、蒸制5 h后、50 ℃烘干等工序加工而成）。

1.2 实验方法

1.2.1 样品提取 精密称取粉碎后过150 μm筛的样品100 g，加入600 mL水，水蒸气回流提取8 h，将提取到的挥发性转移至离心管中，并用2 mL正己烷冲洗容器内壁，涡旋3 min，取正己烷层，从中准确吸取20 μL于1 mL容量瓶中，用正己烷稀释并定容，即得供试品溶液。生晒参和红参按照炮制前后重量比例提取制备。

1.2.2 GC-MS操作条件 GC条件：TG-5SILMS非极性色谱柱（30 m×0.25 mm×0.25 μm）。进样口

2016-11-29收稿，2016-12-20修回，2017-01-20接受
国家自然科学基金资助项目（3140040275）
通讯联系人：越皓，研究员；Tel：0431-86763986；Fax：0431-86763987；E-mail：yuehao@sohu.com；研究方向：天然产物的色谱质谱分析

温度为250 ℃,初始温度50 ℃,保持3 min;升温程序,从50 ℃开始,先以5 ℃/min升至120 ℃,再以1 ℃/min升至125 ℃,保持3 min,再以1 ℃/min升至130 ℃,保持3 min,再以1 ℃/min升至135 ℃,保持3 min,再以1 ℃/min升至140 ℃,保持3 min,再以1 ℃/min升至145 ℃,保持3 min,再以1 ℃/min升至150 ℃,保持3 min;载气为He,载气流量为1.2 mL/min;分流比为35,进样量为1 μL。

MS条件:EI离子源,进样口温度270 ℃,离子源温度250 ℃,传输线温度250 ℃,扫描范围50~500m/z。

2 结果与讨论

2.1 挥发性成分的定性分析

从图1可以看出,鲜参、生晒参和红参中的挥发性成分差异较大,在化合物数量和含量方面,炮制前后及不同方法炮制均对挥发性成分有显著的影响。

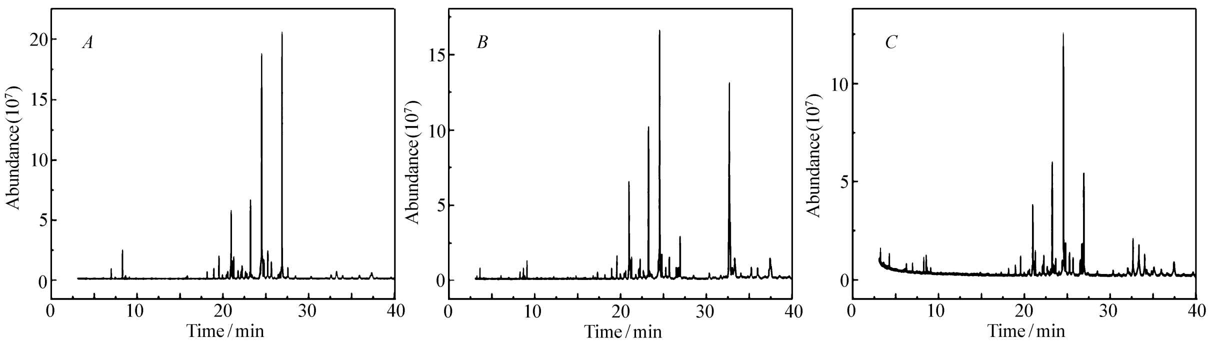


图1 鲜参总离子色谱图(A)、生晒参总离子色谱图(B)和红参总离子色谱图(C)

Fig.1 The total ion chromatography of the fresh ginseng(A), the sun-dry(B) and the red ginseng(C)

GC-MS由于具有恒定的70 eV电离能和标准数据库,因此能够不使用标准对照品,鉴定挥发性成分[16-17]。本研究通过GC-MS/MS一级质谱图分子量和二级串联质谱子离子信息,与NIST MS Spectral Database数据库比对,鉴定了40个人参中的挥发性化合物,具体如表1所示。

表1 鲜参、生晒参、红参挥发性成分定性分析

Table 1 The volatile components in qualitative analysis of fresh ginseng, sun-dry ginseng and red ginseng

No.	Retention time/min	Compounds	Formula	Molecular mass	Relative peak area		
					Fresh ginseng	Sun-Dry ginseng	Red ginseng
1	6.96	α-Pinene	$C_{10}H_{16}$	136	1	0.24	0.77
2	7.43	Camphene	$C_{10}H_{16}$	136	1	0.17	0.53
3	8.27	β-Pinene	$C_{10}H_{16}$	136	1	0.24	0.38
4	8.66	Ningene	$C_{10}H_{16}$	136	1	1.98	1.05
5	9.07	Octanal	$C_8H_{10}O$	128	1	4.90	1.70
6	15.85	Benzene,2-methoxy-4-methyl-1-(1-methyl)-	$C_{11}H_{16}O$	164	1	0.48	–
7	16.78	Cyclodecanone	$C_{10}H_{18}O$	154	–	+	+
8	17.31	6-(5-Methyl-furan-2-yl)-hexan-2-one	$C_{11}H_{16}O_2$	180	–	++	+
9	18.13	Cedrene	$C_{15}H_{24}$	204	1	0.51	0.76
10	18.93	β-Elemene	$C_{15}H_{24}$	204	1	0.71	0.61
11	19.14	4,4,6-Trimethyl-cyclohex-2-en-1-ol	$C_9H_{16}O$	140	–	+	–
12	19.52		$C_{14}H_{20}O$	204	1	0.83	0.56
13	19.93	2-(3-Isopropyl-4-methyl-pent-3-en-1-ynyl)-2-methyl-cyclobutanone	$C_{14}H_{20}O$	204	1	1.11	0.72
14	20.95	Ginsengene	$C_{15}H_{24}$	204	1	1.29	0.67
15	21.24	Caryophyllene	$C_{15}H_{24}$	204	1	0.77	0.70
16	21.76	Neoclovene	$C_{15}H_{24}$	204	1	–	0.40

Continued on next page

continued from previous page

No.	Retention time/min	Compounds	Formula	Molecular mass	Relative peak area		
					Fresh ginseng	Sun-Dry ginseng	Red ginseng
17	22.22	Aromadendrene	$C_{15}H_{24}$	204	1	1.15	0.89
18	22.64	Aristolene	$C_{15}H_{24}$	204	1	0.90	0.77
19	23.21	α-Elemene	$C_{15}H_{24}$	204	1	1.52	0.89
20	23.65	Farnesene	$C_{15}H_{24}$	204	−	−	++
21	24.50	Transcaryophyllene	$C_{15}H_{24}$	204	1	0.88	0.68
22	24.76	Ai Li Mo phenol	$C_{15}H_{24}$	204	1	1.09	1.04
23	25.22	β-Selinene	$C_{15}H_{24}$	204	1	0.32	0.49
24	25.63	δ-Cadinene	$C_{15}H_{24}$	204	1	1.05	0.58
25	26.47	á-Guaiene	$C_{15}H_{24}$	204	−	++	−
26	26.63	1*H*-Cycloprop[e]azulene,1a,2,3,5,6,7,7a,7b-octahydro-1,1,4,7-tetramethyl-,[1aR-(1aà,7à,7aá,7bà)]-	$C_{15}H_{24}$	204	1	1.21	2.97
27	26.87	Azulene,1,2,3,3a,4,5,6,7-octathydro-1,4,dimethyl-7-(1-methylethenyl)-,[1R,(1à,3aá,4à,7á)]-	$C_{15}H_{24}$	204	1	0.16	0.27
28	27.56	Naphthalene,1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methylthemyl)-,[1R-(1à,7á,8aà)]-	$C_{15}H_{24}$	204	++	−	−
29	28.44	1-(1,5-dimethylhexyl)-4-methylbenzene	$C_{15}H_{24}$	204	1	0.93	1.10
30	30.26		$C_{15}H_{26}O$	222	1	1.86	1.66
31	32.04	New ginseng terpene alcohols	$C_{15}H_{26}O$	222	−	−	++
32	32.61	(−)-Spathulenol	$C_{15}H_{24}O$	220	1	31.98	5.47
33	33.24	β-Piperonyl butylene	$C_{15}H_{24}$	204	1	1.86	−
34	33.35	Globulol	$C_{15}H_{26}O$	222	−	−	++
35	33.94	ξ-EIMACHALENE	$C_{15}H_{26}O$	222	1	1.42	4.32
35	34.83	7-*epi*-*cis*-Sesquisabinene	$C_{15}H_{26}O$	222	−	−	++
37	35.02	à-Acorenol	$C_{15}H_{26}O$	222	1	−	3.74
38	35.22	Caryophyllene oxide	$C_{15}H_{24}O$	220	−	++	−
39	35.97	4-*epi*-Cubedol	$C_{15}H_{26}O$	222	−	++	+
40	37.42	2*H*-3,9a-Methanol-1-benzoxepin,octahydro-2,2,5a,9-tetramethyl-,[3R-(3à,5aà,9à,9aà)]-	$C_{15}H_{26}O$	222	1	2.10	1.35

In the table: the peak area of compound in fresh ginseng was 1 and the relationship area of processed ginseng was calculated by ratio between the amount of processed ginseng and fresh ginseng. "−": none of the components, "+": indicates the peak area of 10^6, "++": peak area is 10^7, "+++": peak area of 10^8.

由表 1 和图 2 可知,鲜参、生晒参和红参中共检测出 40 种挥发性成分,其中烯类 22 种,醛类 1 种,酮类 3 种,醇类 8 种,杂环类 6 种。鲜参共中检测出烯类 20 种挥发性成分,醛类 1 种,酮类 1 种,醇类 4 种,杂环类 4 种,共 30 种挥发性成分;生晒参中检测出烯类 20 种,醛类 1 种,酮类 3 种,醇类 4 种,杂环类 5 种,共 33 种挥发性成分;红参中检测出烯类 19 种,醛类 1 种,酮类 3 种,醇类 8 种,杂环类 3 种,共

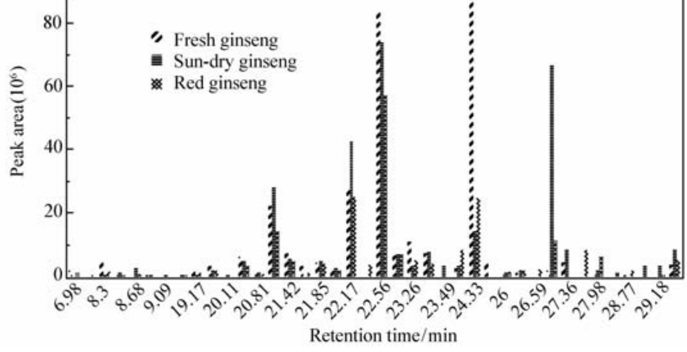


图 2　鲜参、生晒参、红参挥发性成分定性分析比较

Fig. 2　The comparison of the volatile compounds in fresh ginseng, sun-dry ginseng and red ginseng

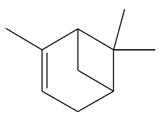
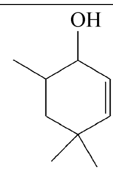
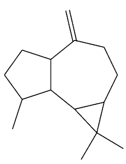
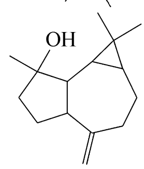
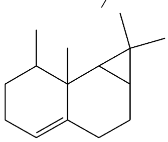
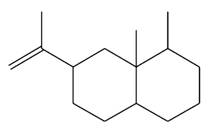
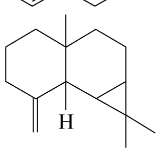
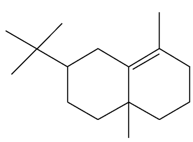
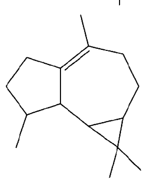
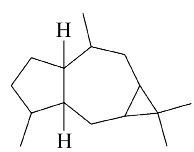
34 种挥发性成分。

2.2 炮制过程中挥发性成分的转化

由图 2 中发性成分研究结果可知，生晒参在阴干或晾干过程中挥发性成分有部分损失，使含量降低或挥发性成分种类减少，有少数新挥发性成分生成；红参由于经过高温蒸制及低温烘干等热处理后，一部分挥发性成分含量明显增高，推测是由与其结构相似的挥发性成分转化而来，使其含量增加。推断炮制后部分发现的新挥发性成分的衍生途径如表 2。

表 2 挥发性成分存在的转化关系

Table 2 Transformation relationship of volatile components

No.	Raw material		Transformation products	
	Structural formula	Compounds	Structural formula	Compounds
1		α-Pinene		4,4,6-Trimethyl-cyclohex-2-en-1-ol
2		Aromandendrene		(－)-Spathulenol
3		α-Elemene		Farnesene
4		Ginsengene		New ginseng terpene alcohols
5		1*H*-Cycloprop[e]azulene, 1a,2,3,5,6,7,7a,7b- octahydro-1,1,4,7-tetramethyl-, [1aR-(1aà,7à,7aá,7bà)]-		Globulol

炮制过程中，鲜参中具有不饱和双键的挥发性成分，加热条件下，易发生加成反应，生成饱和的或部分饱和的加成产物。人参中化学成分含量较多且相互作用复杂，红参的炮制过程中化学成分之间相互作用，有大量酶参与反应，故一些含量较高的成分不能确定是由结构相似的化合物转化而得，其生成过程有待进一步研究和讨论。

生晒参中(－)-斯巴醇含量为鲜参含量的 31.98 倍，为红参含量的 5.84 倍，是生晒参中检测出最多的挥发性成分。研究表明，(－)-斯巴醇属聚炔醇类化合物，是五加科植物中较常见的成分，具有很强的抗肿瘤活性，可抑制血管紧张素 II 诱导的血管收缩，降低自发性高血压大鼠平均动脉压，同时还具有抗炎及抗血小板凝集活性。人参脂溶性成分(含聚醇类)具明显促进神经细胞生长的活性，可降低血压、降血脂及对冠心病患者有食疗作用[18-21]。由于鲜参、生晒参和红参中艾里莫酚烯含量均相对较高，且可能转化为(－)-斯巴醇，由此可见鲜参在晾晒成生晒参时，一部分艾里莫酚烯转化为(－)-斯巴醇，使生晒参在抗肿瘤活性、降血压、降血脂方向的作用更加明显。

红参中金合欢烯是鲜参和生晒参中均不含有的特有成分，有报道[22]称金合欢醇具有消炎健胃作用，民间将金合欢醇用于治疗风湿扭伤等病，符合无梗五加在《中华本草》中传统药理的记载。由于鲜参中不含该成分，不具有该功效，但由于鲜参中含有的 α-橄香烯含量较红参高，且在鲜参炮制成红参的过程中可能转化为金合欢烯，故红参较鲜参增加了消炎健胃的作用。

3 结　论

本文通过气相色谱-质谱联用方法,检测了鲜参、生晒参、红参中的挥发性成分,并对炮制前后差异较大的化合物进行了衍生规律推测,结合已报道的化合物生物活性,从挥发性成分的角度阐释了人参炮制品的物质基础,为人参的临床应用和规范化炮制质量控制提供了化学数据支持。

参 考 文 献

[1] DAI Yulin, YUE Hao, SUN Changjiang, *et al*. Determination of Ginsenosides in Processed Ginseng by Rapid Resolution Liquid Chromatography Coupled with Quadrupole-Time-of-Flight Tandem Mass Spectrometry[J]. *Chinese J Anal Chem*, 2015, **43**(8): 1181-1186(in Chinese).
戴雨霖,越皓,孙长江,等. 高分离度快速液相色谱-四极杆-飞行时间质谱法分析酒制和醋制人参的皂苷类成分[J]. 分析化学, 2015, **43**(8): 1181-1186.

[2] XU Jing, JIA Li, ZHAO Yuqing. Constituents of Ginseng and Quality Evaluation of Ginseng Products[J]. *Drug Eval Res*, 2011, **34**(3): 199-202(in Chinese).
徐静,贾力,赵余庆. 人参化学成分与人参产品的质量评价[J]. 药物评价研究, 2011, **34**(3): 199-202.

[3] LI Jing, DAI Yulin, ZHENG Fei, *et al*. Oral Absorption and *in vivo* Biotransformation of Ginsenosides[J]. *Chinese J Biol*, 2014, **27**(12): 1633-1636(in Chinese).
李晶,戴雨霖,郑飞,等. 人参皂苷的口服吸收及体内转化[J]. 中国生物制品学杂志, 2014, **27**(12): 1633-1636.

[4] HAN Dong, ZHANG Tiejun, TANG Cheng, *et al*. Research Progress on Pharmacokinetics of Panax Ginseng Saponins[J]. *Chinese Tradit Herb Drugs*, 2009, **40**(2): fu1-fu3(in Chinese).
韩冬,张铁军,唐铖,等. 人参皂苷的药动学研究进展[J]. 中草药, 2009, **40**(2): 附 1-附 3.

[5] REN Ming, HAO Xiaoshi, YE Lingyan, *et al*. Extraction and Isolation of Polysaccharide from Ginseng and Its Anti-tumor Activity *in vitro*[J]. *J Jilin Univ*(Med Ed), 2014, **40**(4): 812-815(in Chinese).
任明,郝筱诗,叶伶艳,等. 人参多糖的提取分离及其体外抗肿瘤作用[J]. 吉林大学学报(医学版), 2014, **40**(4): 812-815.

[6] ZHAO Hua, WEI Jianhua, XU Tao, *et al*. Analysis of Volatile Oil Components of Panax Ginseng by GC-MS[J]. *Ginseng Res*, 2014, (3): 45-48(in Chinese).
赵花,魏建华,徐涛,等. 人参挥发油成分的 GC-MS 分析[J]. 人参研究, 2014, (3): 45-48.

[7] YANG Ling, DAN Dan, ZHU Rui, *et al*. β-Elemene Inhibits Expression of ANG Ⅱ and RhoA/ROCK Signaling in Hepatic Stellate Cells[J]. *J Chinese Mater Med*, 2009, **34**(4): 458-462(in Chinese).
杨玲,但丹,朱锐,等. β-榄香烯抑制肝星状细胞表达 ANG Ⅱ 及 RhoA/ROCK 信号[J]. 中国中药杂志, 2009, **34**(4): 458-462.

[8] XU Liying, ZHANG Xingzhong, DU Huilian, *et al*. Synthesis and Antitumor Activity of β-Elemene Derivatives Bearing Amino Acid Moiety[J]. *Chinese J Med Chem*, 2013, **23**(3): 169-175(in Chinese).
徐莉英,张兴忠,杜惠莲,等. β-榄香烯氨基酸衍生物的合成及抗肿瘤活性[J]. 中国药物化学杂志, 2013, **23**(3): 169-175.

[9] Kobaisy M, Abramowski Z, Lermer L, *et al*. Antimycobacterial Polyynes of Devil's Club(*Oplopanax horridus*), a North American Native Medicinal Plant[J]. *J Nat Prod*, 1997, **60**: 1210-1213.

[10] Sohn J, Lee C H, Chung D J, *et al*. Effect of Petroleum Ether Extract of Panax Ginseng Roots on Proliferation and Cell Cycle Progression of Human Renal Cell Carcinoma Cells[J]. *Exp Mol Med*, 1998, **30**(1): 47-51.

[11] DUAN Xianchun, XIA Lunzhu, WANG Yongzhong, *et al*. Protective Effects of Panaxynol on Nerve Cells under Oxygen and Glucose Deprivation[J]. *Chinese J Exp Tradit Med Formulae*, 2011, **17**(16): 180-183(in Chinese).
段贤春,夏伦祝,汪永忠,等. 人参炔醇对氧糖剥夺神经细胞损伤的保护作用[J]. 中国实验方剂学, 2011, **17**(16): 180-183.

[12] Xing J, Sun H M, Li Z Y, *et al*. Comparison of Volatile Components Between Raw and Vinegar Baked Radix Bupleuri by GC-MS Based Metabolic Fingerprinting Approach[J]. *Evid-Based Compl Alter Med*, 2015: 1-7.

[13] Aranda-Rodriguez R, Cabecinha A, Harvie J, *et al*. A Method for Quantification of Volatile Organic Compounds in Blood by SPME-GC-MS/MS with Broader Application: From Non-Occupational Exposure Population to Exposure Studies[J]. *J Chromatogr B Anal Technol Biomed Life Sci*, 2015, (992): 76-85.

[14] Ma X Y, Zhang L H, Shao H B. Jerusalem Artichoke(*Helianthus tuberosus* L.), a Medicinal Salt-Resistant Plant has High Adaptability and Multiple-Use Values[J]. *J Med Plants Res*, 2011, **5**(8): 1275-1282.

[15] Zead H, Khaldun M Al A, Yuliya T, *et al*. Analysis of Essential Oil in Jerusalem Artichoke(*Helianthus tuberosus* L.) Leaves and Tubers by Gas Chromatography-Mass Spectrometry[J]. *Adv Pharm Bull*, 2014, **4**(Suppl 2): 521-526.

[16] MAHEMUTI Maimaitiming, MILIBAN Nuojia, MAERHABA Wusiman. Analysis of Volatile Oils and Fatty Acids in Tamarix Chinensis Fruit[J]. *Chinese J Appl Chem*, 2015, **32**(2): 239-244(in Chinese).
马合木提·买买提明,米丽班·霍加,玛尔哈巴·吾斯满. 柽柳实中挥发油和脂肪酸分析[J]. 应用化学, 2015, **32**(2): 239-244.
[17] LI Xiaoli, LIU Baofeng, XIE Wenbing, *et al*. The Contrastive Analysis of Puffballs Produced from Inner Mongolia and Jilin [J]. *Chinese J Appl Chem*, 2012, **29**(4): 477-482(in Chinese).
李小丽,刘宝峰,谢文兵,等. 内蒙和吉林产地马勃的对比分析[J]. 应用化学, 2012, **29**(4): 477-482.
[18] LIN Zhaozhan, ZHU Chenchen, ZHANG Cuixian, *et al*. Studies on Chemical Constituents and Antioxidant Activity of Essential Oil from Leaves of Eucommia[J]. *J Trop Subtrop Botany*, 2009, **17**(4): 401-405(in Chinese).
林朝展,祝晨蔯,张翠仙,等. 杜虹花叶挥发油化学成分及抗氧化活性研究[J]. 热带亚热带植物学报, 2009, **17**(4): 401-405.
[19] Shinji T, Denan J, Kazuyoshi K, *et al*. Effects of a Lipoxygenase Inhibitor, Panaxynol, on Vascular Contraction Induced by Angiotensin II[J]. *Jpn J Pharm*, 1999, **80**(1): 89-92.
[20] Fujimoto Y, Sakuma S, Komatsu S, *et al*. Inhibition of 15-Hydroxyprostahlandin Dehydrogenase Activity in Rabbit Gastricantral Mucosa by Panaxynol Isolated from Oriental Medicines[J]. *J Pharm Pharmacol*, 1998, **50**(9): 1075-1078.
[21] ZOU Kun, ZHU Shu, CAI Shaoqing, *et al*. HPLC/UV Analysjs of Lipid Extract from Panax Ginseng Roots with Neural Outgrowth Activity[J]. *J China Three Gorges Univ*(Nat Sci), 2002, **24**(4): 155-160(in Chinese).
邹坤,朱姝,蔡少青,等. HPLC结合API-MS/MS研究扣子七的人参皂甙[J]. 三峡大学学报(自然科学版), 2002, **24**(4): 155-160.
[22] SONG Yang. Optimization of Extraction Technology and Chemical Constituents of Volatile Oil from Root of the Root[J]. *Shanxi Med J*, 2014, **43**(5): 487-489(in Chinese).
宋洋. 无梗五加根挥发油提取工艺的优化及其化学成分研究[J]. 山西医药杂志, 2014, **43**(5): 487-489.

Analysis of Volatile Components in Processed Ginseng by GC-MS/MS

WANG Wei, ZHENG Fei, GE Yan, QIAO Mengdan, YUE Hao*, LIU Shuying
(*Jilin Ginseng Academy, Changchun University of Chinese Medicine, Changchun* 130117, *China*)

Abstract The research of chemical changes in ginseng processing has been focusing on saponins and sugars. In this paper, volatile components in ginseng were studied for the first time, which provide a substance basis for different processed ginseng. The volatile components and their derivative paths of fresh ginseng, sun-dry ginseng and red ginseng were studied by gas chromatography-mass spectrometry(GC-MS/MS). The volatile components were detected and analyzed using TG-5SILMS nonpolar GC column, with He as the carrier gas through the NIST MS Spectral Database. Thirty, thirty-three and thirty-four species of volatile compounds in fresh ginseng, sun-dry ginseng and red ginseng were detected, respectively. The content of (−)-spartak alcohol in sun-dry ginseng is 31.98 times higher than that in the fresh ginseng, while the levels of eight volatile components such as octanal in sun-dry ginseng is three times higher than those in the fresh ginseng. The contents of ten volatile components such as cyclodecanone in red ginseng are 3 times higher than those in the fresh ginseng. Four volatile compounds in sun-dry ginseng and in red ginseng are not detected in fresh ginseng.

Keywords gas chromatography-mass spectrometry; fresh ginseng; sun-dry ginseng; red ginseng; volatile compound

Received 2016-11-29; Revised 2016-12-20; Accepted 2017-01-20
Supported by the National Natural Science Foundation of China(No. 3140040275)

Corresponding author: YUE Hao, professor; Tel: 0431-86763986; Fax: 0431-86763987; E-mail: yuehao@sohu.com; Research interests: analysis of natural product by LC-MS