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五味子科药用植物亲缘学初探

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A preliminary pharmacophylogenetic investigation in Schisandraceae

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Abstract The family Schisandraceae (Magnoliiadae) contains approximately sixty species which are disjunctly distributed in the southeast of Asia and North America. It was divided into two genera, *Schisandra* and *Kadsura,* represented by 29 species in China, 19 in *Schisandra* and 10 in *Kadsura.* This paper reviews current knowledge about the chemistry, ethnopharmacology and pharmacology of the family in an attempt to present a preliminary study into the pharmacophylogenetics of the family as a whole. Dibenzocyclooctadiene lignans (I) are considered to be the main chemical components of the family. Despite their traditionally recognized hepatoprotective function, they also exhibit anti-oxidant, anti-cancer and anti-HIV potential. Those dibenzocyclooctadiene lignans (I) possessing hydroxyl or angeloyloxy groups at C-6 or C-9 in the ethylidene-cyclooctane ring tend to exhibit a higher anti-cancer activity. Spirobenzofuranoid dibenzocyclooctadienes (II), mostly present in *Kadsura*, contain a special tetrahydrofuran ring spanning the biphenyl linkage and these demonstrate particular anti-PAF activities. This supports the traditional use of *Kadsura* to improve blood circulation and "remove dampness". Spirobenzofuranoid dibenzocyclooctadienes (II) could be considered as the bioactive marker compounds in *Kadsura* and hence markers for assessing quality. The distribution of all known lignans in the family showed that *Kadsura* is relatively advanced in evolution. Cycloartanone triterpenes occur in both *Schisandra* and *Kadsura.* Those with the A-ring open (II) tend to exhibit greater anti-cancer and anti-HIV activity. 7/7/5/6 triterpene lactones (IV), showing strong cytotoxicity, have only recently been discovered in *Kadsura longipedunculata* and as such have potential as anticancer agents. Recently, novel nortriterpenoids possessing a unique skeleton were found in *S. lancifolia* and *S. micrantha;* some exhibited clear anti-cancer or anti-HIV activity and are the subject of separate studies.
Key words chemotaxonomy, ethnopharmacology, pharmacophylogenetics, Schisandraceae.

摘要 五味子科Schisandraceae隶属于双子叶植物门木兰亚纲Magnoliidae八角目Illiciales, 全球分布约60种, 包括两个属: 五味子属*Schisandra*和南五味子属*Kadsura*, 间断分布于亚洲东南部和北美东南部。本文归纳了中国五味子科植物两大类活性成分——木脂素和三萜的分布规律、传统疗效和现代药理活性, 并对中国五味子科的药用植物亲缘学进行了初探。联苯环辛烯类木脂素(I)集中分布于五味子科植物, 可以被认为是五味子科植物的特征性化学成分, 除了传统的保肝作用外, 这类化合物中很多具有潜在的抗氧化、抗肿瘤和抗HIV活性, 一些联苯环辛烯类的木脂素, 尤其是在八元环C-6、C-9位上具有羟基或者酯化取代具有更好的抗HIV和抗肿瘤活性; 而螺苯骈呋喃型联苯环辛烯类木脂素(II)绝大多数存在于南五味子属, 其特殊的螺苯骈呋喃环及其钙拮抗、抗凝血和抑制血小板聚集的活性, 不仅初步说明了民间南五味子属药用植物藤茎具有较强活血化瘀药理作用的活性物质基础, 也提示在对南五味子属的药材质量标准研究中, 可以考虑以此类成分作为定性定量指标。五味子科植物中木脂素成分的分布规律提示, 在演化程度上五味子属植物较南五味子属植物更原始。环菠萝蜜烷类三萜在五味子属和南五味子属均有分布, 尤其是A环开环的环菠萝蜜烷类三萜(II)在抗HIV和抗肿瘤活性方面具有很好的潜力, 而结构更进化的7/7/5/6型三萜内酯(IV)显示了很强的细胞毒活性, 目前只在南五味子属的长梗南五味子*K. longipedunculata*中发现。从五味子属的小花五味子*S. micrantha*和狭叶五味子*S. lancifolia*中分离得到的多个成环复杂且高度氧化的类三萜内酯中也发现具有抗肿瘤和抗HIV潜力。
关键词 化学分类学; 传统药物学; 药用植物亲缘学; 五味子科

五味子科Schisandraceae隶属于双子叶植物门木兰亚纲Magnoliidae八角目Illiciales, 包括两个属: 五味子属*Schisandra* Michx.和南五味子属*Kadsura* Kaempf. ex Juss.。该科植物为木质藤本, 共约60种,

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间断分布于亚洲东南部和北美东南部。我国是世界上五味子科植物资源最丰富的国家, 两属均产, 主要分布于中南部和西南部。五味子属约30种, 主产于亚洲东部和东南部, 仅1种*Schisandra glabra* (Brickell) Rehder产于美国东南部, 我国约有19种, 南北均有分布; 南五味子属约28种, 主产于亚洲东部和东南部, 我国约有10种, 相对集中于西南部和东南部。

1 五味子科植物分类学研究概况

Brickell (1803年2月底–3月初)发表*Stellandria glabra* Brickell, 同年4月, Michaux发表*Schisandra coccinea* Michx., 属名*Stellandria*长期被忽视。Rehder (1944)建议保留*Schisandra* Michx.作为五味子属的学名, 并以Brickell的植物为基本名, 确定五味子属的模式种*Schisandra glabra* (Brickell) Rehder, 被人们沿用至今。1810年, de Jussieu发表南五味子属*Kadsura* Kaempf. ex Juss.的学名, Dunal (1817)以Linnaeus的植物为基本名, 确定了南五味子属的模式种为*Kadsura japonica* (L.) Dunal。1830年, Blume正式描述了五味子科“Schizandreae”, 提出它与木兰科Magnoliaceae近缘。Don (1831)将该名扩改为Schizandraceae。1947年Smith发表《Schisandraceae》专著, 对五味子科进行了全面研究, 将*Schisandra*属分为4组, 并对南五味子属进行了属下分类, 包括22种。

五味子科建立以来, 中外学者们运用形态学、孢粉学、胚胎学与细胞学、现代分子系统学等多种手段对该科的系统位置、两属之间关系及属下分类进行了大量的研究。对于五味子科的系统位置, 传统上一致认为五味子科和木兰科关系很近, 它们在花的形态上特性一致, 因此很长一段时间五味子类被放在木兰科中。随着各个分支学科的研究发展, 五味子科的系统发育工作不断丰富和完善, 人们在研究中发现五味子类和木兰科相差甚远, 晚近的分类学家(Lawrence, 1915; Cronquist, 1968; Takhtajan, 1969; Thorne, 1992)将原隶属于木兰科的木兰族、八角族和五味子族分别独立为三个科。而八角科和五味子科由于在很多性状上有别于木兰亚纲其他类群而被另立为八角目(胡先骕, 1950; Heywood, 1971; Dahlgren et al., 1985; Cronquist, 1988; Takhtajan, 1997)。五味子科从传统的木兰科中分出, 独立为科, 目前已被大多数学者接受, 且多方面证据支持它与八角科形成一个很紧密的类群, 其共同特征为具三沟或其衍生类型的花粉和毛茛型Ranalean type的分泌细胞(Bailey & Nast, 1948), Smith (1947)揭示此两科都是出自同一个祖干上的明显衍生物, 但向不同方向特化而每个有各自的某些原始特征保留。杨志荣和林祁(2007)通过比较五味子科与八角科Illiciaceae的木材解剖特征, 进一步证明两个科的亲缘关系很近, 不支持将五味子科从八角目Illiciales中独立出来成立五味子目Schisandrales的观点。五味子科分为五味子属和南五味子属两个类群, 也得到多方面的支持, 为植物分类学界所接受, 大多数学者认可传统2属的划分, 其区别主要在于雌花花托倒卵形或椭圆形(南五味子属)或圆锥至圆柱形(北五味子)。但到底哪一个属原始哪一个属进化, 似乎仍不统一, 且各有证据。目前主要有三种观点: 1. 五味子属系统位置在南五味子属之前(Smith, 1947), 2. 南五味子属系统位置在五味子属之前(刘玉壶, 1984), 3. 两属起源于共同祖先, 平行进化或沿不同路线演化(孙成仁, 2000; 王彦涵等, 2003)。至于五味子科的属下分类, 分歧更多, 较具有代表性的有: Smith (1947)在五味子属下设4组: 多蕊五味子组sect. *Pleiostema* A. C. Smith (包括华中五味子群和大花五味子群)、少蕊五味子组sect. *Maximowiczia* (Rupr.) Law、五味子组sect. *Schisandra*、团蕊五味子组sect. *Sphaerostema* (Blume) Y. H. Law (包括团蕊五味子群和重瓣五味子群); 将南五味子属分为3个组: 离蕊南五味子组sect. *Cosbaea* (Lem.) Law、南五味子组sect. *Kadsura*和南洋五味子组sect. *Sarcocarpon* (Blume) A. C. Smith。刘玉壶(1996)在中国五味子科的属下等级划分中将Smith系统中组的等级升至亚属, 同时将华中五味子群与大花五味子群分开, 团蕊五味子群和重瓣五味子群分开, 设置6个亚属; 在南五味子属下, 合并离蕊南五味子组、南五味子组于离蕊南五味子亚属subgen. *Cosbaea* (Lem.) Law, 设立2个亚属, 分别为离蕊南五味子亚属subgen. *Cosbaea* (Lem.) Law和南五味子亚属subgen. *Kadsura*。Saunders (1998)在五味子属中设亚属和组两个属下等级, 将华中五味子群与大花五味子群分开, 分置多蕊五味子亚属subgen. *Pleiostema* (A. C. Smith) Law和中华五味子亚属subgen.

Sinoschisandra Law, 保留Smith系统的少蕊五味子组、五味子组和团蕊五味子组, 并将其置于五味子亚属subgen. *Schisandra* (Blume) Y. H. Law之中; 同时Saunders (1998, 2000)支持刘玉壶关于在南五味子属下建立2个亚属的观点, 并在后一个亚属中保留了Smith系统的2个组。比较这三个学者的分类系统, 主要分歧在五味子属下的分类, 包括华中五味子群与大花五味子群是否分开; 团蕊五味子群和重瓣五味子群是否分开; 组和亚属的分类等级能否体现五味子属的进化历程和进化层次。关于南五味子属下分类, 意见相对比较统一, 但属下类群的系统关系, 不同研究得出的结论还存在着分歧, 如王彦涵等(2003)对南五味子属下几个类群的*rbc*L基因分析的结果与其形态学是相互矛盾的。

近些年, 许多学者又通过各种方法对五味子科的分类系统进行修正。林祁(2000, 2002)在野外调查的基础上, 结合大量标本考证, 对世界范围的五味子属和南五味子属作出分类学订正, 并确认五味子属10种, 南五味子属11种。Liu等(2006)分析了五味子科的核DNA ITS和叶绿体DNA *trnL-F*基因序列, 构建了五味子科的系统发育, 认为五味子科分为两大支: 一支完全是由五味子属*Schisandra*的种组成; 另一支则既包含了五味子属的种, 又包含南五味子属*Kadsura*的种, 即将Smith (1947)系统中五味子属的团蕊五味子组结合到南五味子属中。林祁和杨志荣(2007)根据五味子属植物的33个形态性状及其性状分析, 经过分支分析, 提出一个新的五味子属分类系统: 将五味子属分为五味子亚属和团蕊五味子亚属subgen. *Sphaerostema* (Blume) Y. H. Law; 将五味子亚属分为多蕊五味子组、少蕊五味子组、中华五味子组sect. *Sinoschisandra* (Y. H. Law) Q. Lin & Z. R. Yang和五味子组。杨志荣和林祁(2007)根据木材解剖性状对五味子科进行UPGMA聚类分析, 所得结果显示南五味子属和五味子属在木材解剖特征方面有一定的交叉和重叠, 这与分子系统学的结论一致, 表明这两个属关系密切, 可能起源于共同的祖先。Wang等(2007)测序了五味子科内14种植物的叶绿体*matK*区和*rpl16*内含子区, 分析得出铁箍散*S. propinqua* (Wall.) Baill. var. *sinensis* Oliv.和重瓣五味子*S. plena* A. C. Smith嵌套在南五味子属内。

综上所述, 有关五味子科的分类、演化和系统地位研究, 目前尚未达到统一的认识。

2 五味子科亲缘关系与化学成分

已有的化学研究结果表明, 木兰科的特征性成分为异喹啉类生物碱和新木脂素, 并无三萜类成分; 木脂素和三萜为五味子科植物的化学特征, 其中联苯环辛烯类木脂素在植物界中集中分布于五味子科, 极少数存在于其亲缘关系较远的植物, 因此联苯环辛烯类木脂素是五味子科的特征性成分, 具有分类学意义, 而木兰科植物中没有发现此类木脂素; 迄今为止, 在五味子科和八角科中未发现生物碱; 而环菠萝蜜烷类型三萜和A环裂环菠萝蜜烷类型三萜在五味子科和八角科中均分离得到, 推测两科有共同起源。因此, 五味子科从传统木兰科中分出, 独立为科, 与八角科亲缘关系较近, 这一观点不仅从形态学、孢粉学、胚胎学以及细胞学方面得到支持, 而且得到了化学分类的佐证。

2.1 五味子植物中的木脂素及其分类学意义

木脂素是五味子科植物中的主要生物活性成分, 结构类型多, 立体化学复杂。迄今为止从该科植物中分到的木脂素有200多个, 根据骨架类型可分为五大类: I. 联苯环辛烯类(dibenzocyclooctadienes; 图1; 表1); II. 螺苯骈呋喃型联苯环辛烯类(spirobenzofuranoid dibenzocyclooctadienes; 图2; 表2); III. 芳基四氢萘类(aryltetralins; 图3; 表3); IV. 二芳基丁烷类(diarylbutanes; 图4; 表4); V. 四氢呋喃类(tetrahydrofurans; 图5; 表5)。

上述5种类型均属于简单木脂素, 从生源途径上来说, 二芳基丁烷类木脂素是其他4类木脂素的生物合成前体, 芳基四氢萘类木脂素和四氢呋喃类木脂素应该是从二芳基丁烷类木脂素衍化而来的, 属相对进化的化学成分; 螺苯骈呋喃型联苯环辛烯类木脂素是具有酚羟基结构的联苯环辛烯类木脂素氧化环合的产物, 也属于进化的化学成分(图6; 表6)。

五大类木脂素在五味子科植物中的分布显示出一定的规律性: 联苯环辛烯木脂素丰富多样, 化合物数为木脂素类的一半以上, 根据构型构象又可分为S-TBC (twist boat chair)(1-89, 138-139), R-TBC (90-116), S-TB (118-133), 其中S-TBC类型木脂素占据一半以上, 联苯环上除了C-4和C-11位有2个芳质子之外, 其他位置(C1-3和C-12-14)均为含氧取代, 包括甲氧基、亚甲二氧基、羟基和酯基, 酯基

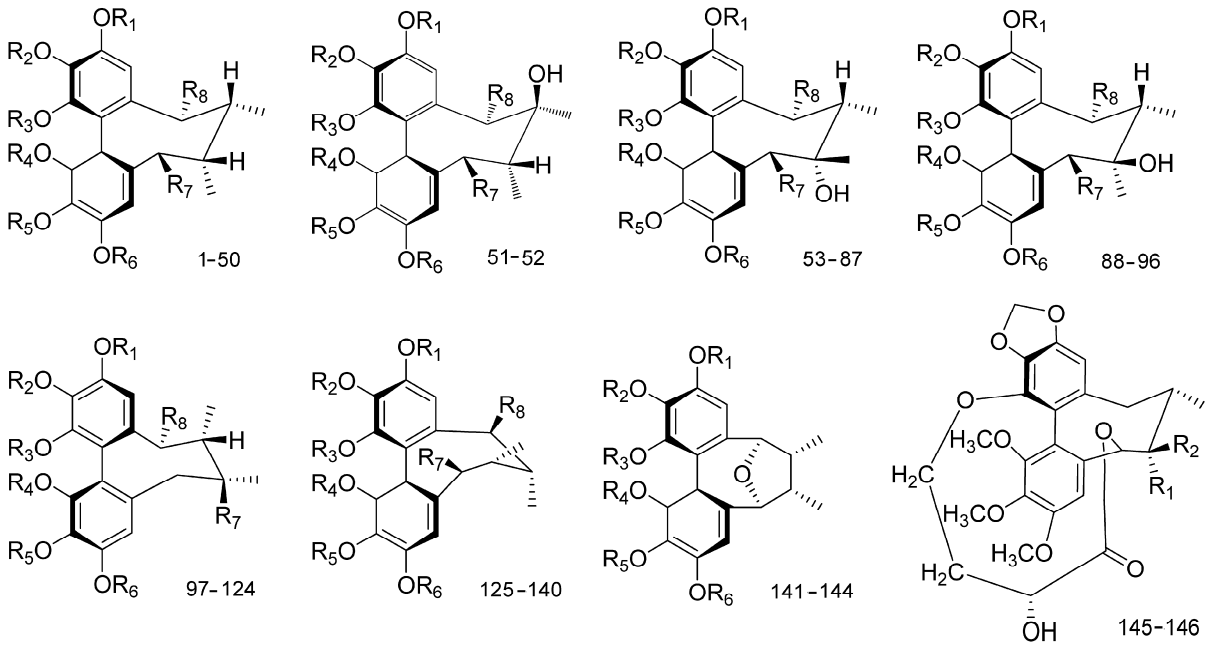


图1 五味子科植物中联苯环辛烯类木脂素成分的结构
Fig. 1. Structures of dibenzocyclooctadienes from Schisandraceae.

表1 五味子科植物中联苯环辛烯类木脂素成分
Table 1 Dibenzocyclooctadienes from Schisandraceae

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
1	schisandrin C (wuweizisu C)	$R_1+R_2=R_5+R_6=CH_2$, $R_3=R_4=CH_3$, $R_7=R_8=H$	五味子*Schisandra chinensis* (Turcz.) Baill. (f, s) 球蕊五味子*S. sphaerandra* Stapf (s) 合蕊五味子*S. propinqua* (Wall.) Baill. (s) 风庆南五味子*Kadsura interior* A. C. Smith (s)	Ikeya et al., 1982b Guo et al., 2003 Chen et al., 2001c Chen et al., 2002a
2	gomisin N	$R_1+R_2=CH_2$, $R_3=R_4=R_5=R_6=CH_3$, $R_7=R_8=H$	五味子*S. chinensis* (f, s) 合蕊五味子*S. propinqua* (s)	Ikeya et al., 1978a Chen et al., 2001a
3	(–)-gomisin K_1	$R_1=R_7=R_8=H$, $R_2=R_3=R_4=R_5=CH_3$	五味子*S. chinensis* (f)	Ikeya et al., 1980a
4	(–)-gomisin L_1	$R_1=R_2=CH_3$, $R_3=R_7=R_8=H$, $R_5+R_6=CH_2$	五味子*S. chinensis* (f)	Ikeya et al., 1982c
5	(–)-gomisin L_2	$R_1=R_7=R_8=H$, $R_2=R_3=CH_3$, $R_5+R_6=CH_2$	五味子*S. chinensis* (f)	Ikeya et al., 1982c
6	gomisin J	$R_1=R_6=R_7=R_8=H$, $R_2=R_3=R_4=R_5=CH_3$	五味子*S. chinensis* (f) 黑老虎*K. coccinea* (Lem.) A. C. Smith (s) 红花五味子*S. rubriflora* (Planch.) Rehd. & Wils. (f)	Ikeya et al., 1978b Li et al., 1985a Chen et al., 2006
7	(–)-rubschisandrin	$R_1=R_2=R_3=R_4=CH_3$, $R_5+R_6=CH_2$, $R_7=R_8=H$	红花五味子*S. rubriflora* (f)	Wang & Chen, 1985
8	kadsurin	$R_1+R_2=CH_2$, $R_3=R_4=R_5=R_6=CH_3$, $R_7=H$, $R_8=OAc$	日本南五味子 *K. japonica* (L.) Dunal (s) 风庆南五味子*K. interior* (s) 异形南五味子*K. Heteroclita* (Roxb.) Craib (s) 红花五味子*S. rubriflora* (s)	Chen et al., 1973 Ding & Luo, 1990 Chen et al., 1992 Li et al., 2004
9	binankadsurin A	$R_1+R_2=CH_2$, $R_3=R_5=R_6=CH_3$, $R_4=R_7=H$, $R_8=OH$	长梗南五味子*K. longipedunculata* Finet & Gagnep. (s) *Kadsura* sp. (s)	Li et al., 1991 Liu & Zhou, 1991
10	acetyl-binankadsurin A	$R_1+R_2=CH_2$, $R_3=R_5=R_6=CH_3$, $R_4=R_7=H$, $R_8=OAc$	日本南五味子*K. japonica* (f) *Kadsura* sp. (s)	Ookawa et al., 1981 Liu & Zhou, 1991
11	angeloyl-binankadsurin A	$R_1+R_2=CH_2$, $R_3=R_5=R_6=CH_3$, $R_4=R_7=H$, $R_8=OAng$	日本南五味子*K. japonica* (f)	Ookawa et al., 1981
12	caproyl-binankadsurin A	$R_1+R_2=CH_2$, $R_3=R_5=R_6=CH_3$, $R_4=R_7=H$, $R_8=OCap$	日本南五味子*K. japonica* (f)	Ookawa et al., 1981
13	benzoyl-binankadsurin A	$R_1+R_2=CH_2$, $R_3=R_5=R_6=CH_3$, $R_4=R_7=H$, $R_8=OBz$	长梗南五味子*K. longipedunculata* (s)	Li et al., 1991

表1 (续) **Table 1** (continued)

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
14	butyryl-binankadsurin A	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=Obutanoyl	*Kadsura* sp. (s)	Liu & Zhou, 1991
15	isovaleroyl-binankadsurin A	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=O-3-methylbutanoyl	长梗南五味子*K. longipedunculata* (s)	Li et al., 1991
16	isobutyroyl-binankadsurin A	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=O-2-methylpropanoyl	长梗南五味子*K. longipedunculata* (s)	Li et al., 1991
17	heteroclitin A	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=H, R_8=O-2-methylbutanoyl	异形南五味子*K. heteroclita* (s) 合蕊五味子*S. propinqua* (s)	Chen et al., 1992 Xu et al., 2006
18	heteroclitin B	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=H, R_8=OAng	异形南五味子*K. heteroclita* (s) 红花五味子*S. rubriflora* (s)	Chen et al., 1992 Li et al., 2004a
19	heteroclitin C	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=H, R_8=OTig	异形南五味子*K. heteroclita* (s) 红花五味子*S. rubriflora* (s)	Chen et al., 1992 Li et al., 2004a
20	angeloylbinankad-surin B	R_1=R_2=R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=OAng	日本南五味子*K. japonica* (f, s)	Ookawa et al., 1995
21	acetylbinankadsurin B	R_1=R_2=R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=OAc	日本南五味子*K. japonica* (f, s)	Ookawa et al., 1995
22	deangeloyl-schisantherin F	R_1=R_4=R_7=H, R_2=R_3=R_5=R_6=CH_3, R_8=OH	日本南五味子*K. japonica* (s)	Ookawa et al., 1995
23	schisantherin F	R_1=R_7=H, R_3=R_5=R_6=CH_3, R_4=Ang, R_8=OH	*Kadsura* sp. (s)	Liu & Ma, 1988a
24	gomisin U	R_1=R_8=H, R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OH	华中五味子*S. sphenanthera* (f)	Ikeya et al., 1991
25	benzoylgomisin U	R_1=R_8=H, R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OBz	华中五味子*S. sphenanthera* (f)	Ikeya et al., 1991
26	tigloylgomisin O	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OTig, R_8=H	华中五味子*S. sphenanthera* (f)	Ikeya et al., 1991 Jiang et al., 2005
27	epigomisin O	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=α-OH, R_8=H	五味子*S. chinensis* (f) 华中五味子*S. sphenanthera* (f) 红花五味子*S. rubriflora* (s)	Ikeya et al., 1979a Ikeya et al., 1991 Chen et al., 2006
28	gomisin S	R_1=R_8=H, R_2=R_3=R_4=R_5=R_6=CH_3, R_7=α-OH, R_8=H	五味子*S. chinensis* (f)	Ikeya et al., 1988a
29	Schisantherin B	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=H	华中五味子*S. sphenanthera* (f) 红花五味子*S. rubriflora* (s)	Liu et al., 1978a Chen et al., 2006
30	schisantherin L	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OAng, R_8=OH	黑老虎*K. coccinea* (s)	Liu & Li, 1993
31	acetylschisanthterin L	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OAng, R_8=OAc	黑老虎*K. coccinea* (s)	Liu & Li, 1993
32	schisantherin M	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OAng, R_8=OTig	黑老虎*K. coccinea* (s)	Liu & Li, 1993
33	schisantherin N	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OAng, R_8=OAng	黑老虎*K. coccinea* (s)	Liu & Li, 1993
34	schisantherin P	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OH, R_8=OH	黑老虎*K. coccinea* (s) 狭叶南五味子*K. angustifolia* (s)	Liu & Li, 1995a Chen et al., 1998a
35	angustifolin A	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OBz, R_8=OBz	狭叶南五味子*K. angustifolia* A. C. Smith (s)	Chen et al., 1998b
36	angustifolin B	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OBz, R_8=OAc	狭叶南五味子*K. angustifolia* (s)	Chen et al., 1998b
37	angustifolin C	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OBz, R_8=OH	狭叶南五味子*K. angustifolia* (s)	Chen et al., 1998b
38	angustifolin D	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OAc, R_8=OAc	狭叶南五味子*K. angustifolia* (s)	Chen et al., 1998a
39	renchangianin C	R_1=R_2=R_5=R_6=CH_3, R_3=R_4=H, R_7=OCin, R_8=OAng	仁昌南五味子*K. renchangiana* S. F. Lan (s)	Chen et al., 2004a
40	rubriflorin A	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=OAc	红花五味子*S. rubriflora* (s)	Li et al., 2004 a
41	propinquanin D	R_1=H, R_2=R_3=R_5=R_6=CH_3, R_4=Ang, R_7=OH, R_8=OAc	合蕊五味子*S. propinqua* (s)	Xu et al., 2006

表1 (续) **Table 1** (continued)

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
42	longipedunin A	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=OCin	长梗南五味子*K. longipedunculata* (s)	Sun et al., 2006
43	longipedunin B	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=OAc	长梗南五味子*K. longipedunculata* (s)	Sun et al., 2006
44	rubriflorin B	R_1=R_2=R_4=R_5=R_6=CH_3, R_3=H, R_7=H, R_8=Oxo	红花五味子*S. rubriflora* (s)	Li et al., 2004a
45	schizanrin L	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=H	日本南五味子*K. japonica* (f, s)	Kuo et al., 2005b
46	ananosin A	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OTig, R_8=OH	中泰南五味子*K. ananosma* Kerr (s)	Chen et al., 2001e
47	acetylgomisin R	R_1+R_2=CH_2,R_3=R_4=CH_3, R_5+R_6=CH_2 R_7=OAc, R_8=H	合蕊五味子*S. propinqua* (s)	Chen et al., 2001a
48	rubrifloralignan A	R_1=R_2=R_5=R_6=CH_3, R_3=R_4=R_7=R_8=H	红花五味子*S. rubriflora* (s)	Tian et al., 2006
49	rubrisandrin A	R_1=R_2=R_4=R_5=CH_3, R_3=R_6=R_7=R_8=H or R_2=R_3=R_5=R_6=CH_3, R_1=R_4=R_7=R_8=H	红花五味子*S. rubriflora* (s)	Chen et al., 2006
50	rubrisandrin B	R_1=R_2=R_5=R_6=CH_3, R_3=R_4=R_7=R_8=H	红花五味子*S. rubriflora* (s)	Chen et al., 2006
51	angeloyl-(+)-gomisin K3	R_1=R_2=R_5=R_6=CH_3, R_3=Ang, R_7=R_8=H	合蕊五味子*S. propinqua* (s)	Lei et al., 2007
52	methylisogomisin O	R_1=R_2=R_3=R_4=CH_3, R_5+R_6=CH_2, R_7=OCH_3, R_8=H	合蕊五味子*S. propinqua* var. *propinqua* (s)	Lei et al., 2007
53	kadsuphilins D	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=H, R_7=OH, R_8=OAc	菲律宾五味子*K. philippinensis* Elm. (s)	Shen et al., 2007
54	kadsuphilins F	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=H, R_7=OH, R_8=OBz	菲律宾五味子*K. philippinensis* (s)	Shen et al., 2007
55	kadsuphilins C	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=H, R_7= OBz, R_8=OAc	菲律宾五味子*K. philippinensis* (s)	Shen et al., 2007
56	kadsuphilins E	R_1=R_2=R_3=R_5=R_6=CH_3, R_4=H, R_7=OH, R_8=OBz	菲律宾五味子*K. philippinensis* (s)	Shen et al., 2007
57	gomisin B	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=H	五味子*S. chinensis* (f) 华中五味子*S. sphenanthera* (f) 长梗南五味子*K. longipedunculata* (s) 合蕊五味子*S. propinqua* 阿里山五味子*S. arisanensis* Hayata (s)	Ikeya et al., 1979c Liu et al., 1978a Li & Chen, 1986 Chen et al., 2001a Wu et al., 2003
58	gomisin C (schisantherin A)	R_1+R_2= CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=H	五味子*S. chinensis* (f) 华中五味子*S. sphenanthera* (f, s) 合蕊五味子*S. propinqua* (s) 翼梗五味子*S. henryi* Clarke (f, s) 凤庆南五味子*K. interior* (s)	Ikeya et al., 1979c Liu et al., 1978a Yue et al., 1994 Chen et al., 2001a Chen et al., 2005b Chen et al., 2002a
59	gomisin F	R_1=R_2=R_3=R_4=CH_3, R_5+R_6=CH_2, R_7=OAng, R_8=H	五味子*S. chinensis* (f)	Taguchi et al., 1977
60	gomisin G	R_1=R_2=R_3=R_4=CH_3, R_5+R_6=CH_2, R_7=OBz, R_8=H	五味子*S. chinensis* (f) 小花五味子*S. micrantha* (s) 翼梗五味子*S. henryi* (s) 阿里山五味子*S. arisanensis* (s) 合蕊五味子*S. propinqua* (s) 凤庆南五味子*K. interior* (s)	Taguchi et al., 1977 Li et al., 2005a Chen et al., 2005 Wu et al., 2003 Chen et al., 2001a Chen et al., 2002a
61	benzoylgomisin Q	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=H	华中五味子*S. sphenanthera* (f, s) 翼梗五味子*S. henryi* (s)	Ikeya et al., 1990 Chen et al., 2005b
62	angeloylgomisin Q	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=H	五味子*S. chinensis* (f)	Ikeya et al., 1979b
63	interiotherin B	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OAng, R_8=H	凤庆南五味子*K. interior* (s)	Chen et al., 1996
64	interiotherin C	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=OAc	凤庆南五味子*K. interior* (s)	Chen et al., 2002a
65	schisantherin C	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OTig, R_8=H	华中五味子*S. sphenanthera* (f) 五味子*S. chinensis* (f)	Liu et al., 1978a Ikeya et al., 1979c

表1 (续) **Table 1** (continued)

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
66	schisantherin D	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OBz, R_8=H	华中五味子*S. sphenanthera* (f) 五味子*S. chinensis* (f) 凤庆南五味子*K. interior* (s)	Liu et al., 1978a Ikeya et al., 1982b Yue et al., 1994 Chen et al., 1996
67	schisantherin E	R_1=R_8=H, R_7=Obz, R_2=R_3=R_4=R_5=R_6=CH_3	华中五味子*S. sphenanthera* (f)	Liu et al., 1978a
68	schisantherin G	R_1+R_2=CH_2, R_3=H, R_8=OAc R_4=R_5=R_6=CH_3, R_7=OAng,	*Kadsura* sp. (s)	Liu & Ma, 1988b
69	schisantherin H	R_1+R_2=CH_2, R_4=H, R_3=R_5=R_6=CH_3, R_7=R_8=OAng	*Kadsura* sp. (s)	Liu & Ma, 1988b
70	schisantherin I	R_1=H, R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=OAc	*Kadsura* sp. (s) 合蕊五味子*S. propinqua* (s)	Liu & Ma, 1988b Xu et al., 2006
71	schisantherin J	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=OIsobutyloyl	长梗南五味子*K. longipedunculata* (s)	Liu & Pan, 1991
72	kadsurarin	R_1+R_2=CH_2, R_3=H, R_4=R_5=R_6=CH_3, R_7=OAng, R_8=OAc	日本南五味子*K. japonica* (s) *K. matsudai* Hayata (s) *Kadsura* sp. (s) 异形南五味子*K. heteroclita* (s)	Chen et al., 1973 Wu et al., 2003 Liu & Ma, 1988b Wang et al., 2006a
73	propinquanin A	R_1=H, R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=OCap	合蕊五味子*S. propinqua* (s)	Xu et al., 2006
74	propinquanin B	R_1=R_4=H, R_2=R_3=R_5=R_6=CH_3, R_7=OBz, R_8=OCap	合蕊五味子*S. propinqua* (s)	Xu et al., 2006
75	propinquanin C	R_1+R_2=CH_2, R_3=H, R_4=R_5=R_6=CH_3, R_7=OAng, R_8=OCap	合蕊五味子*S. propinqua* (s)	Xu et al., 2006
76	heteroclitalignan A	R_1+R_2=CH_2, R_3=H, R_4=R_5=R_6=CH_3, R_7=OAc, R_8=OBz	异形南五味子*K. heteroclita* (s)	Wang et al., 2006a
77	heteroclitalignan B	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=OProp	异形南五味子*K. heteroclita* (s)	Wang et al., 2006a
78	heteroclitalignan D	R_1+R_2=CH_2, R_3=OH, R_4=R_5=R_6=CH_3, R_7=OAc, R_8=OBz	异形南五味子*K. heteroclita* (s)	Wang et al., 2006a
79	schizanrin I	R_1+R_2=CH_2, R_3=H, R_4=R_5=R_6=CH_3, R_7=OBz, R_8=OBz	日本南五味子*K. japonica* (s)	Kuo et al., 2005b
80	schizanrin J	R_1+R_2=CH_2, R_3=H, R_8=OAng R_4=R_5=R_6=CH_3, R_7=OTig	日本南五味子*K. japonica* (s)	Kuo et al., 2005b
81	schizanrin K	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OTig, R_8=Oxo	日本南五味子*K. japonica* (s)	Kuo et al., 2005b
82	schizanrin F	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=OAc	*K. matsudai* (s)	Wu et al., 2003
83	schizanrin G	R_1+R_2=CH_2, R_3=H, R_8=OAc R_4=R_5=R_6=CH_3, R_7=OAng	*K. matsudai* (s)	Wu et al., 2003
84	schizanrin H	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=OAc	*K. matsudai* (s)	Wu et al., 2003
85	renchangianin A	R_1=R_2=R_5=R_6=CH_3, R_3=R_4=H, R_7=OBz, R_8=OAc	仁昌南五味子*K. renchangiana* (s)	Chen et al., 2004a
86	renchangianin B	R_1=R_2=R_5=R_6=CH_3, R_3=R_4=H, R_7=OBz, R_8=OAng	仁昌南五味子*K. renchangiana* (s)	Chen et al., 2004a
87	renchangianin D	R_1=R_2=R_5=R_6=CH_3, R_3=R_4=H, R_7=OBz, R_8=OAng , 7 (spirocyclic epoxy)	仁昌南五味子*K. renchangiana* (s)	Chen et al., 2004a
88	deangeloylgomisin B	R_1+R_2= CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=H, R_8=H	五味子 *S. chinensis* (f)	Ikeya et al., 1979a
89	benzoylgomisin P	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=H	华中五味子*S. sphenanthera* (f)	Ikeya et al., 1990
90	tigloylgomisin P	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OTig, R_8=H	五味子*S. chinensis* (f) 合蕊五味子*S. propinqua* (s) 红花五味子*S. rubriflora* (s)	Ikeya et al., 1978a Chen et al., 2001c Chen et al., 2006
91	angeloylgomisin P	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=H	五味子*S. chinensis* (f) 华中五味子*S. sphenanthera* (f) 红花五味子*S. rubriflora* (s)	Ikeya et al., 1980b Ikeya et al., 1990 Chen et al., 2006
92	schizanrin A	R_1+R_2=CH_2, R_3=R_7=H, R_4=R_5=R_6=CH_3, R_8=Cin	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1999

表1 (续) **Table 1** (continued)

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
93	schizanrin B	R_1+R_2=CH_2, R_3=R_7=H, R_4=R_5=R_6=CH_3, R_8=Oiso-valeroyl	*K. matsudai* (s)	Kuo et al., 2001
94	schizanrin C	R_1+R_2=CH_2, R_3=R_7=H, R_4=R_5=R_6=CH_3, R_8=OCap	*K. matsudai* (s)	Kuo et al., 2001
95	schizanrin D	R_1+R_2=CH_2, R_3=R_7=H, R_4=R_5=R_6=CH_3, R_8=Oac	*K. matsudai* (s)	Kuo et al., 2001
96	schizanrin E	R_1+R_2=CH_2, R_3=R_7=H, R_4=R_5=R_6=CH_3, R_8=OBz	*K. matsudai* (s)	Kuo et al., 2001
97	(±)-kadsutherin	R_1=R_2=R_4=R_5=R_6=CH_3, R_3=Ang, R_7=R_8=H	黑老虎*K. coccinea* (s)	Li et al., 1985
98	(+)-deoxyschizandrin (schisandrin A, wuweizisu A)	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=R_8=H	五味子*S. chinensis* (f, s) 华中五味子*S. sphenanthera* (f, s) 合蕊五味子*S. propinqua* (s) 红花五味子*S. rubriflora* (s)	Chen et al., 1976 Liu et al., 1978b Zhao et al., 1999 Jiang et al., 2005 Chen et al., 2006
99	(+)-γ-schisandrin (schisandrin B, wuweizisu B)	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=R_8=H	五味子*S. chinensis* (f, s) 华中五味子*S. sphenanthera* (f, s)	Chen et al., 1976 Ikeya et al., 1979a
100	(+)-gomisin K_2	R_1=R_7=R_8=H, R_2=R_3=R_4=R_5=R_6=CH_3,	五味子*S. chinensis* (f)	Ikeya et al., 1980a
101	(+)-gomisin K_3	R_1=R_2=R_4=R_5=R_6=CH_3, R_3=R_7=R_8=H	五味子*S. chinensis* (f) 华中五味子*S. sphenanthera* (f) 阿里山五味子*S. arisanensis* (s) 小花五味子*S. micrantha* (s)	Ikeya et al., 1980a Ikeya et al., 1990 Yue et al., 1994 Wu et al., 2003 Li et al., 2005a
102	schisanhenol	R_1=R_2=R_3=R_5=R_6=CH_3, R_4=R_7=R_8=H	翼梗五味子*S. henryi* (f) 五味子*S. chinensis* (f) 红花五味子*S. rubriflora* (f, s) 中间五味子*S. propinqua* var. *intermedia* A. C. Smith (s)	Liu et al., 1978b Chen et al., 1982 He et al., 1997 Li et al., 1996
103	schisanhenol acetate	R_1=R_2=R_4=R_5=R_6=CH_3, R_3=Ac, R_7=R_8=H	红花五味子*S. rubriflora* (f, s) 五味子*S. chinensis* (f)	Wang & Chen, 1985 Ikeya et al., 1980
104	(±)-gomisin M_1	R_1=R_2=R_4=CH_3, R_5+R_6=CH_2, R_3=R_7=R_8=H	五味子*S. chinensis* (f) 长梗南五味子*K. longipedunculata* (s) 红花五味子*S. rubriflora* (f, s)	Ikeya et al., 1982c Tan et al., 1984 Chen et al., 2006
105	r(+)-angeloylgomisin M_1	R_1=R_2=R_4=CH_3, R_5+R_6=CH_2, R_3=Ang, R_7=R_8=H	长梗南五味子*K. longipedunculata* (s)	Tan et al., 1984
106	(+)gomisin M_2	R_1=R_2=R_3=CH_3, R_5+R_6=CH_2, R_4=R_7=R_8=H	五味子*S. chinensis* (f) 长梗南五味子*K. longipedunculata* (s) 红花五味子*S. rubriflora* (f, s)	Ikeya et al., 1982c Li et al., 1985 Chen et al., 2006
107	kadsuranin	R_1=R_2=R_3=R_4=CH_3, R_5+R_6=CH_2, R_7=R_8=H	长梗南五味子*K. longipedunculata* (s)	Tan et al., 1984
108	schisantherin O	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=OAc	黑老虎*K. coccinea* (s)	Liu & Li, 1993
109	gomisin A (schisandrol B)	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OH, R_8=H	五味子*S. chinensis* (f, s) 异形南五味子*K. heteroclita* (s) 凤庆南五味子*K. interior* (s) 长梗南五味子*K. longipedunculata* (s)	Ikeya et al., 1979c Chen et al., 1976 Chen et al., 1997 Chen et al., 2002a Li & Chen, 1986
110	schisandrin (schisandrol A)	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OH, R_8=H	五味子*S. chinensis* (f) 长梗南五味子*K. longipedunculata* (s) 红花五味子*S. rubriflora* (f)	Ikeya et al., 1979c Li & Chen, 1986 Chen et al., 2006
111	gomisin H	R_1=R_2=R_4=R_5=R_6=CH_3, R_7=OH, R_3=R_8=H	五味子*S. chinensis* (f) 黑老虎*K. coccinea* (s)	Ikeya et al., 1979d Li et al., 1985
112	angeloylgomisin H	R_1=R_2=R_4=R_5=R_6=CH_3, R_3=Ang, R_7=OH, R_8=H	五味子*S. chinensis* (f) 长梗南五味子*K. longipedunculata* (s)	Ikeya et al., 1978c Li & Chen, 1986
113	tigloylgomisin H	R_1=R_2=R_4=R_5=R_6=CH_3, R_3=Tig, R_7=OH, R_8=H	五味子*S. chinensis* (f)	Ikeya et al., 1978c
114	benzoylgomisin H	R_1=R_2=R_4=R_5=R_6=CH_3, R_3=Tig, R_7=OH, R_8=H	五味子*S. chinensis* (f)	Ikeya et al., 1978c
115	gomisin T	R_2=R_3=R_4=R_5=R_6=CH_3, R_1=R_8=H, R_7=OH	五味子*S. chinensis* (f)	Ikeya et al., 1988a

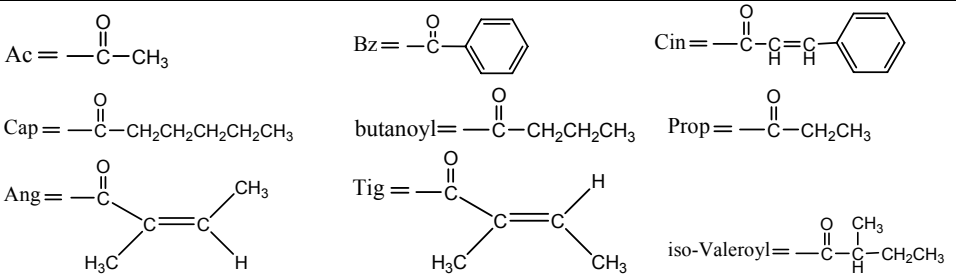
表1 (续) **Table 1** (continued)

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
116	isoschizandrin	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=OH, R_8=H	五味子*S. chinensis* (f)	Ikeya et al., 1988b
117	schisanlignone A	R_1=R_2=R_3=R_4=R_5=R_6=CH_3, R_7=H, R_8=Oxo	*Kadsura* sp. (s)	Liu & Zhou, 1991
118	schisanlignone B	R_2=R_3=R_4=R_5=R_6=CH_3, R_1=R_7=H, R_8=Oxo	*Kadsura* sp. (s)	Liu & Zhou, 1991
119	schisanlignone C	R_1=R_2=R_3=R_4=CH_3, R_5+R_6=CH_2, R_7=H, R_8=Oxo	绿叶五味子*S. viridis* A. C. Smith (s)	Luo et al., 1992a
120	schisanlignone D	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=H, R_8=Oxo	绿叶五味子*S. viridis* (s)	Luo et al., 1992a
121	schisanlignone E	R_1+R_2=CH_2, R_4=R_5=R_6=CH_3, R_3=Bz, R_8=Oxo	绿叶五味子*S. viridis* (s)	Luo et al., 1992a
122	schisanhenol B	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=R_8=H	红花五味子*S. rubriflora* (f)	Wang et al., 1985
123	longipedunin C	R_1+R_2=CH_2, R_3=R_5=R_6=CH_3, R_4=R_7=H, R_8=Bz	长梗南五味子*K. longipedunculata* (s)	Sun et al., 2006
124	micrantherin A	R_1=R_2=R_3=R_5=R_6=CH_3, R_4=R_7=R_8=H (C_8-OAng)	小花五味子*S. micrantha* (s)	Li et al., 2005a
125	gomisin O	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OH, R_8=H	五味子*S. chinensis* (f) 合蕊五味子*S. propinqua* (s) 红花五味子*S. rubriflora* (f)	Ikeya et al., 1979a Chen et al., 2001c Chen et al., 2006
126	angeloylgomisin O	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAng, R_8=H	五味子*S. chinensis* (f) 合蕊五味子*S. propinqua* (s)	Ikeya et al., 1982a Chen et al., 2001c
127	angeloylisogomisin O	R_1=R_2=R_3=R_4=CH_3, R_5+R_6=CH_2, R_7=OAng, R_8=H	五味子*S. chinensis* (f) 合蕊五味子*S. propinqua* (s)	Ikeya et al., 1982a Chen et al., 2001c
128	6-O- benzoylgomisin O	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OBz, R_8=H	五味子*S. chinensis* (f) 合蕊五味子*S. propinqua* (s)	Chen et al., 1994 Chen et al., 2001c
129	benzoylisogomisin O	R_1=R_2=R_3=R_4=CH_3, R_5+R_6=CH_2, R_7=OBz, R_8=H	五味子*S. chinensis* (f) 合蕊五味子*S. propinqua* (s)	Ikeya et al., 1982a Chen et al., 2001c
130	gomisin R	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OH, R_8=H	五味子*S. chinensis* (f)	Ikeya et al., 1982b
131	schisantherin Q	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=Oxo, R_8=OH	黑老虎*K. coccinea* (s)	Liu & Li, 1995a
132	angeloylgomisin R	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OAng, R_8=H	长梗南五味子*K. longipedunculata* (s) 风庆南五味子*K. interior* (s) 合蕊五味子*S. propinqua* (s)	Tan et al., 1984 Chen et al., 1997 Chen et al., 2001a
133	interiotherin A	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=OBz, R_8=H	风庆南五味子*K. interior* (s)	Chen et al., 1996
134	rubschisantherin	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=OAc, R_8=H	红花五味子*S. rubriflora* (f)	Wang & Chen, 1985
135	schisanlignaol D	R_1+R_2=R_5+R_6=CH_2, R_3=R_4=CH_3, R_7=H, R_8=OH	绿叶五味子*S. viridis* (s)	Luo et al., 1992a
136	schisantherin K	R_1=R_2=R_3=R_5=R_6=CH_3, R_4=Tig, R_7=OAc, R_8=OH	绿叶五味子*S. viridis* (s)	Luo et al., 1992b
137	yunnankadsurin A	R_1+R_2=CH_2, R_3=R_4=R_5=CH_3, R_6=OH, R_7=Oxo, R_8=H	*Kadsura* sp. (s)	Jia et al., 2005
138	yunnankadsurin B	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3, R_7=H, R_8=OH	*Kadsura* sp. (s)	Jia et al., 2005
139	schizanrin M	R_1+R_2=CH_2, R_3=R_4=R_5=CH_3, R_6=R_8=H, R_7=Oxo	日本南五味子*K. japonica* (s)	Kuo et al., 2005b
140	schizanrin N	R_1=R_2=R_3=CH_3, R_4=R_8=H, R_5+R_6=CH_3, R_7=Oxo	日本南五味子*K. japonica* (s)	Kuo et al., 2005b
141	kadsulignan L	R_1+R_2=CH_2, R_3=R_4=R_5=R_6=CH_3	黑老虎*K. coccinea* (s) 狭叶南五味子*K. angustifolia* (s) 合蕊五味子*S. propinqua* (s)	Liu & Li, 1995b Chen et al., 1998a Chen et al., 2001c
142	kadsulignan M	R_1+R_2=CH_2, R_3=R_4=R_5=CH_3, R_6=H	黑老虎*K. coccinea* (s)	Liu & Li, 1995b
143	kadsulignan N	R_1=R_2=R_3=R_4=R_5=R_6=CH_3,	黑老虎*K. coccinea* (s) 狭叶南五味子*K. angustifolia* (s)	Liu & Li, 1995b Chen et al., 1998a
144	neokadsuranin	R_1=R_2=R_3=R_4=CH_3, R_5+R_6= CH_2	黑老虎*K. coccinea* (s) 风庆南五味子*K. interior* (s)	Li et al., 1988 Chen et al., 2002a

表1 (续) **Table 1** (continued)

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
145	gomisin D	R_1=CH_3, R_2=OH	五味子*S. chinensis* (f)	Ikeya et al., 1976
146	gomisin E	R_1=H, R_2= CH_3	五味子*S. chinensis* (f)	Ikeya et al., 1979a

1)



2) f, 果实; s, 茎。f, fruits; s, stems.

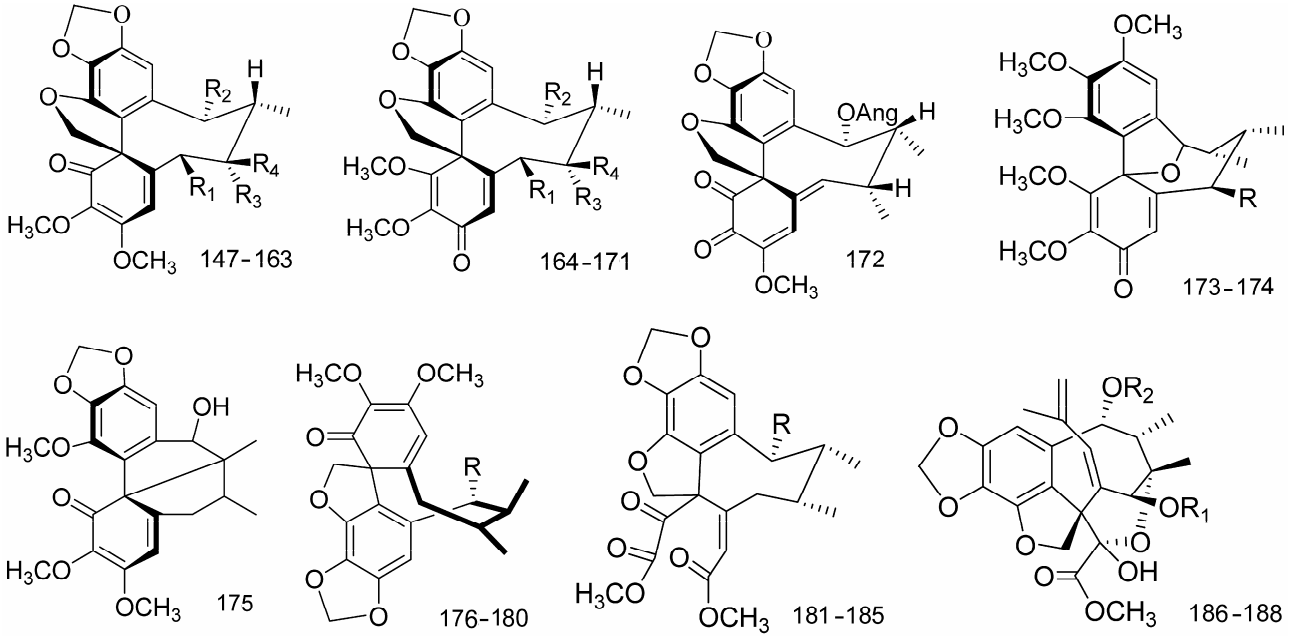


图2 五味子科植物中螺苯骈呋喃型联苯环辛烯类木脂素成分的结构
Fig. 2. Structures of spirobenzofuranoid dibenzocyclooctadienes from Schisandraceae.

表2 五味子科植物中螺苯骈呋喃型联苯环辛烯类木脂素
Table 2 Spirobenzofuranoid dibenzocyclooctadienes from Schisandraceae

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
147	heteroclitin D	R_1=R_4=H, R_2=OAng, R_3=CH_3	异形南五味子*Kadsura heteroclita* (s) 红花五味子*Schisandra rubriflora* (s) 凤庆南五味子*K. interior* (s)	Chen et al., 1992 Li et al., 2004a Chen et al., 2002a
148	heteroclitin E	R_1=OH, R_2=OAng, R_3=CH_3, R_4=H	异形南五味子*K. heteroclita* (s)	Chen et al., 1992
149	isovaleroyloxokadsurane	R_1=R_4=H, R_2=Oisovaleroyl, R_3=CH_3	长梗南五味子*K. longipedunculata* (s) 黑老虎*K. coccinea* (s)	Li et al., 1991 Li & Xue, 1990
150	acetoxyloxokadsurane	R_1=R_4=H, R_2=OAc, R_3=CH_3	黑老虎*K. coccinea* (s)	Li & Xue, 1990
151	benzoyloxokadsurane	R_1=R_4=H, R_2=OBz, R_3=CH_3	黑老虎*K. coccinea* (s)	Li & Xue, 1990

表2 (续) **Table 2** (continued)

序号 No.	化合物名称 Compound	结构[1)] Structure[1)]	来源植物[2)] Plant source[2)]	文献 Reference
152	propoxyloxokadsurane	R_1=R_4=H, R_2=OProp, R_3=CH_3	黑老虎*K. coccinea* (s)	Li & Xue, 1990
153	kadsulignan H	R_1=R_4=H, R_2=Obutanoyl, R_3=CH_3	*Kadsura* sp. (s)	Liu et al., 1992
154	kadsulignan I	R_1=R_4=H, R_2=OProp, R_3=CH_3	*Kadsura* sp. (s)	Liu et al., 1992
155	kadsulignan J	R_1=R_4=H, R_2=Oiso-Valeroyl, R_3=CH_3	*Kadsura* sp. (s)	Liu et al., 1992
156	heterociltin E	R_1=OH, R_2=OAng, R_3=CH_3, R_4=H	异形南五味子*K. heteroclita* (s)	Chen et al., 1992
157	isovaleroyloxokad-suranol	R_1=OH, R_2= OIsovaleroyl, R_3=CH_3, R_4=H	黑老虎*K. coccinea* (s)	Li & Xue, 1990
158	heteroclitin I	R_1=OBz, R_2=OAng, R_3=CH_3, R_4=H	异形南五味子*K. heteroclita* (s)	Xu et al., 2007
159	heteroclitin J	R_1=OBz, R_2=OAc, R_3=CH_3, R_4=H	异形南五味子*K. heteroclita* (s)	Xu et al., 2007
160	heteroclitin K	R_1=OBz, R_2=OBz, R_3=CH_3, R_4=H	异形南五味子*K. heteroclita* (s)	Xu et al., 2007
161	heteroclitin L	R_1=OAng, R_2=OBz, R_3=CH_3, R_4=H	异形南五味子*K. heteroclita* (s)	Xu et al., 2007
162	kadsulignan C	R_1=OAc, R_2=OBz, R_3=OH, R_4=CH_3	长梗南五味子*K. longipedunculata* (s)	Liu et al., 1991
163	kadsulignan D	R_1=R_2=OAng, R_3=OH, R_4=CH_3	长梗南五味子*K. longipedunculata* (s)	Liu et al., 1991
164	interiorin	R_1=R_4=H, R_2=OAng, R_3=CH_3	凤庆南五味子*K. interior* (s) 异形南五味子*K. heteroclita* (s) 红花五味子*S. rubriflora* (s)	Shide et al., 1988 Chen et al., 1992 Li et al., 2004a
165	interiorin B	R_1=R_4=H, R_2=OTig, R_3=CH_3	凤庆南五味子*K. interior* (s) 红花五味子*S. rubriflora* (s)	Ding & Luo, 1990 Li et al., 2004
166	interiorin C	R_1=R_4=H, R_2=OAc, R_3=CH_3	凤庆南五味子*K. interior* (s)	Ding & Luo, 1990
167	interiorin D	R_1=R_4=H, R_2=OBz, R_3=CH_3	凤庆南五味子*K. interior* (s)	Ding & Luo, 1990
168	heteroclitalignan C	R_1=OAng, R_2=OProp, R_3=OH, R_4=CH_3	异形南五味子*K. heteroclita* (s)	Wang et al., 2006a
169	kadsulignan E	R_1=OAc, R_2=OBz, R_3=OH, R_4=CH_3	长梗南五味子*K. longipedunculata* (s) 异形南五味子*K. heteroclita* (s)	Liu & Huang, 1992 Wang et al., 2006a
170	kadsulignan F	R_1=OAng, R_2=OAc, R_3=OH, R_4=CH_3	长梗南五味子*K. longipedunculata* (s)	Liu & Huang, 1992
171	kadsulignan G	R_1=R_2=OAng, R_3=OH, R_4=CH_3	长梗南五味子*K. longipedunculata* (s)	Liu & Huang, 1992
172	interiotherin D		凤庆南五味子*K. interior* (s)	Chen et al., 2002a
173	kadsulignan A	R=H	黑老虎*K. coccinea* (s)	Liu et al., 1989
174	kadsulignan B	R=OAc	黑老虎*K. coccinea* (s)	Liu et al., 1989
175	kadsulignan K		*Kadsura* sp. (s)	Liu et al., 1992
176	schiarisanrin A	R=Oiso-valeroyl	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1997
177	schiarisanrin B	R=OAc	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1997
178	schiarisanrin C	R=OBz	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1997
179	schiarisanrin D	R=OCin	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1997
180	schiarisanrin E	R=OAng	阿里山五味子*S. arisanensis* (s)	Wu et al., 2003
181	heteroclitin F	R=OAng	异形南五味子*K. heteroclita* (s) 凤庆南五味子*K. interior* (s)	Yang et al., 1992 Chen et al., 2002a
182	taiwanschirin A	R=Oiso-valeroyl	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1999
183	taiwanschirin B	R=OAc	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1999
184	taiwanschirin C	R=OBz	阿里山五味子*S. arisanensis* (s)	Kuo et al., 1999
185	taiwanschirin D	R=OCap	*K. matsudai* (s)	Li et al., 2000
186	taiwankadsurin A	1-OH, R_1=Bz, R_2=Ac	菲律宾五味子*K. philippinensis* (s)	Shen et al., 2005b
187	taiwankadsurin B	1-OH, R_1=Bz, R_2=Ac	菲律宾五味子*K. philippinensis* (s)	Shen et al., 2005b
188	taiwankadsurin C	R_1=Ac, R_2=Bz	菲律宾五味子*K. philippinensis* (s)	Shen et al., 2005b

1)、2) 注释同表1。1) , 2) are the same as in Table 1.

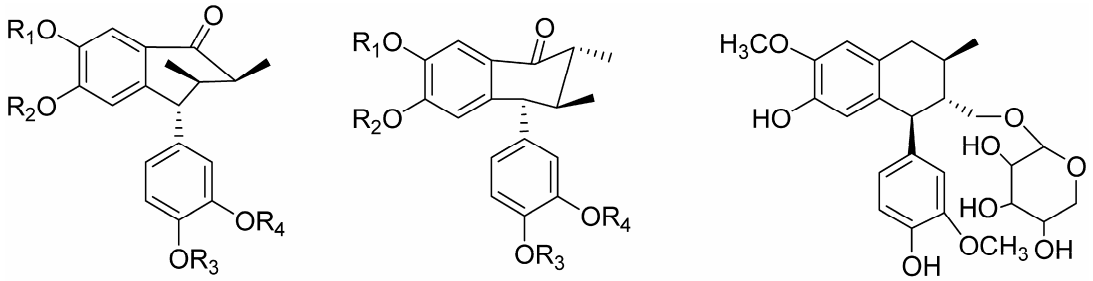


图3 五味子科植物中芳基四氢萘类木脂素成分的结构
Fig. 3. Structures of Aryltetralins from Schisandraceae.

表3 五味子科植物中芳基四氢萘类木脂素
Table 3 Aryltetralins from Schisandraceae

序号 No.	化合物名称 Compound	结构 Structure	来源植物[1)] Plant source[1)]	文献 Reference
189	schisandrone	R_1=H, R_2=R_3=R_4=CH_3	翼梗五味子*Schisandra henryi* (f) 华中五味子*S. sphenanthera* (f)	Liu et al., 1988b Li & Xue, 1985b
190	enshicine	R_1+R_2=CH_2, R_3=H, R_4=CH_3	翼梗五味子*S. henryi* (f)	Liu et al., 1984b
191	wulignan A_1	R_1=R_3=H, R_2=R_4=CH_3	翼梗五味子*S. henryi* (f)	Liu et al., 1988b
192	epienshicine	R_1+R_2=CH_2 , R_3=H, R_4=CH_3	翼梗五味子*S. henryi* (f) 铁箍散*S. propinqua* (Wall.) Baill. var. *sinensis* Oliv. (f)	Liu et al., 1988b Liu et al., 1988a
193	epienshicine methyl ether	R_1+R_2=CH_2 , R_3=R_4=CH_3	翼梗五味子*S. henryi* (f)	Tao et al., 1991
194	epischisandrone	R_1=H, R_2=R_3=R_4=CH_3	翼梗五味子*S. henryi* (f)	Liu et al., 1988b
195	epiwulignan A_1	R_1=R_3= H, R_2=R_4=CH_3	翼梗五味子*S. henryi* (f)	Liu et al., 1988b
196	wulignan A_2	R_1=R_4=CH_3, R_2=R_3=H	翼梗五味子*S. henryi* (f)	Liu et al., 1988b
197	schizandriside		*S. nigra* Maxim. (s)	Takahashi & Takani, 1975

1) f, 果实; s, 茎。f, fruits; s, stems.

表4 五味子科植物中二芳基丁烷类木脂素
Table 4 Diarylbutanes from Schisandraceae

序号 No.	化合物名称 Compound	结构 Structure	来源植物[1)] Plant source[1)]	文献 Reference
198	pregomisin	R_1=R_4=OH, R_2=R_3=R_5=R_6=OCH_3	五味子*Schisandra chinensis* (f) 红花五味子*S. rubriflora* (s) 中间五味子*S. propinqua* var. *intermedia* (s)	Ikeya et al., 1978b Wang & Chen, 1985 Li et al., 1996
199	preschisanthrin	R_1=R_3=R_4=R_6=OCH_3, R_2=R_5=OH	中间五味子*S. propinqua* var. *intermedia* (s)	Li et al., 1996
200	(+)-anwulignan	R_1+R_2=OCH_2O, R_3=R_4=H, R_5=OH, R_6=OCH_3	长梗南五味子*K. longipedunculata* (s) 华中五味子*S. sphenanthera* (f, s)	Liu & Huang, 1988 Jiang et al., 2005
201	dl-anwulignan	R_1=OCH_3, R_2=OH, R_3=R_4=H, R_5+R_6=OCH_2O	华中五味子*S. sphenanthera* (f)	Liu & Huang, 1984a
202	mesodihydroguaiaretic acid	R_1=R_6=OCH_3, R_3=R_4=H, R_2=R_5=OH	五味子*S. chinensis* (f) 长梗南五味子*Kadsura longipedunculata* (s) 红花五味子*S. rubriflora* (f) 狭叶南五味子*K. angustifolia* (s) 异形南五味子*K. heteroclita* (s)	Chen et al., 2005a Liu & Huang, 1991 Wang & Chen, 1985 Chen et al., 1998a Wang et al., 2006a
203	isoanwulignan	R_1=H, R_2=OH, R_3=OCH_3, R_4=H, R_5+R_6=OCH_2O	绿叶五味子*S. viridis* (s) 翼梗五味子*S. henryi* (f)	Luo et al., 1992b Chen et al., 2005b
204	nordihydroguaiaretic acid	R_1=R_2=R_5=R_6=OH, R_3=R_4=H	五味子*S. chinensis* (f)	Sakurai et al., 1992
205	sphenanlignan	R_1+R_2=OCH_2O, R_3=H, R_4=R_5=OCH_3, R_6=OH	华中五味子*S. sphenanthera* (f)	Jiang et al., 2005
206	lengfantuanjing I	R_1=R_4=H, R_2=OH, R_3=OCH_3, R_5+R_6=OCH_2O	黑老虎*K. coccinea* (s)	Liu & Wang, 1989
207	lignandiol		红花五味子*S. rubriflora*	Wang et al., 1993

1) f, 果实; s, 茎。f, fruits; s, stems.

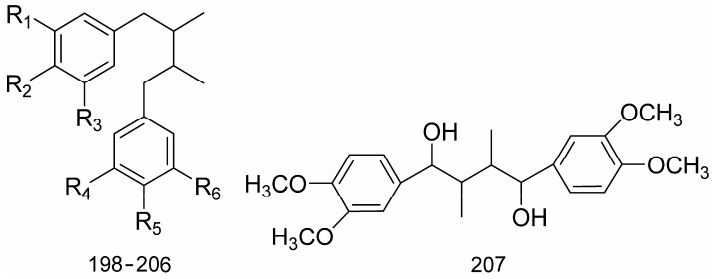


图4 五味子科植物中二芳基丁烷类木脂素成分的结构
Fig. 4. Structures of diarylbutanes from Schisandraceae.

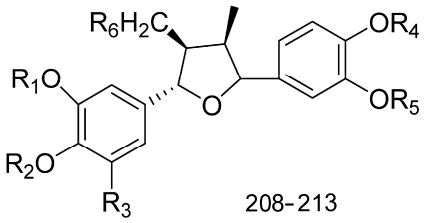


图5 五味子科植物中四氢呋喃类木脂素成分的结构
Fig. 5. Structures of tetrahydrofurans from Schisandraceae.

表5 五味子科植物中四氢呋喃类木脂素
Table 5 Tetrahydrofurans from Schisandraceae

序号 No.	化合物名称 Compound	结构 Structure	来源植物[1)] Plant source[1)]	文献 Reference
208	chicanine	R_1+R_2=CH_2, R_3=R_4=R_6=H, R_5=CH_3	华中五味子*Schisandra sphenanthera* (s)	Liu et al., 1981
209	d-epigalbacin	R_1+R_2=R_4+R_5=CH_2, R_3=R_6=H	华中五味子*S. sphenanthera* (s) 异形南五味子*Kadsura heteroclita* (s)	Huang et al., 1982a Wang et al., 2006a
210	ganschisandrine	R_1=R_2=R_4=R_5=CH_3, R_3=R_6=H	华中五味子*S. sphenanthera* (s)	Yue et al., 1989
211	veraguensin	R_1=R_2=R_4=R_5=CH_3, R_3=R_6=H	*Kadsura* sp. (s)	Liu & Huang, 1988
212	henricine	R_1=R_2=CH_3, R_3=OCH_3, R_4+R_5=CH_2, R_6=H	翼梗五味子*S. henryi* (s)	Li & Xue, 1986a
213	enshizhisu	R_1+R_2=CH_2, R_3=R_4=H, R_5=CH_3, R_6=OH	翼梗五味子*S. henryi* (s)	Huang et al., 1982b

1) f, 果实; s, 茎。f, fruits; s, stems.

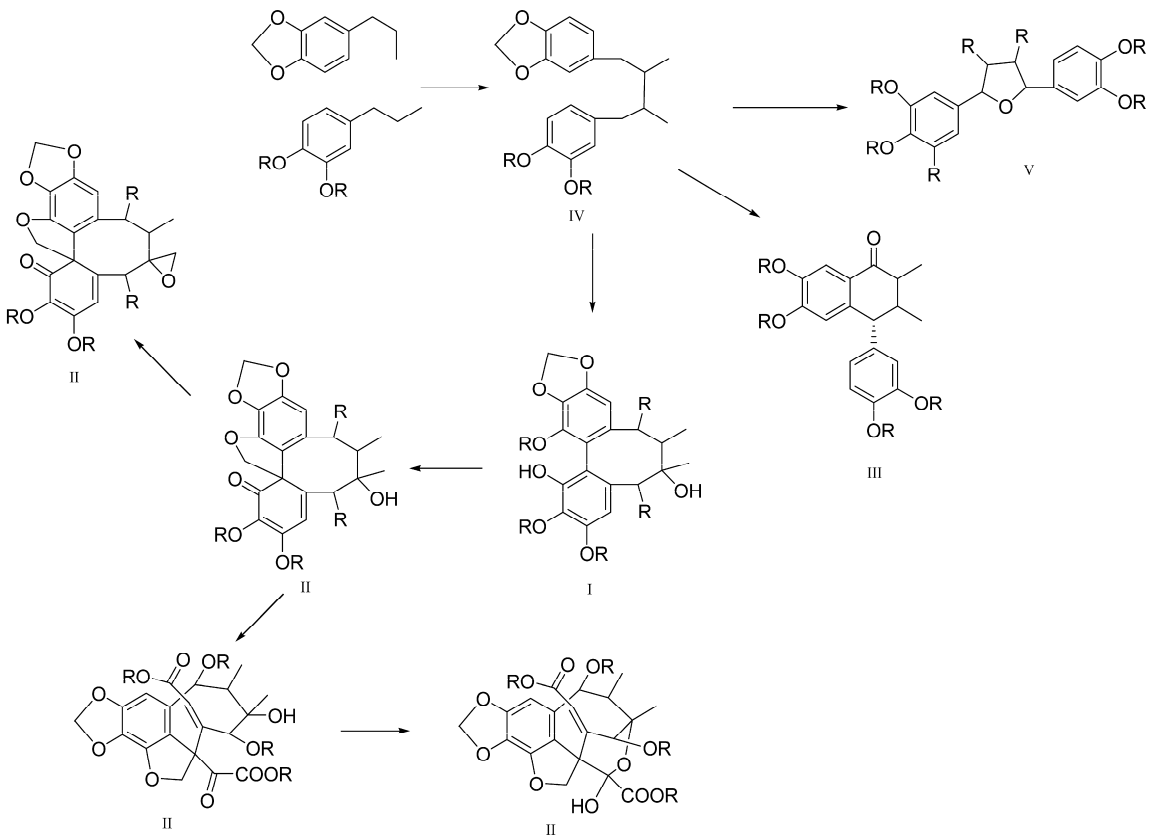


图6 五味子科植物中各类木脂素类型之间的演化关系(徐任生, 2004; Shen et al., 2005b)
Fig. 6. Proposed biogenetic relationships between different lignan types in Schisandraceae (Xu, 2004; Shen et al., 2005b).

表6 木脂素在五味子科药用植物中的分布
Table 6 Distribution of lignans in the family Schisandraceae

种 Species	木脂素 Lignans				
	I 联苯环辛烯类 Dibenzocycloocta-dienes	II 螺苯骈呋喃型联苯环辛烯类 Spirobenzofuranoid dibenzo-cyclooctadienes	III 芳基四氢萘类 Aryltetralins	IV 二芳基丁烷类 Diarylbutanes	V 四氢呋喃类 Tetrahydrofurans
五味子*Schisandra chinensis*	42			3	
华中五味子*S. sphenanthera*	16		1	3	3
红花五味子*S. rubriflora*	25	3		3	
翼梗五味子*S. henryi*	4		8	1	2
绿叶五味子*S. viridis*	5			1	
合蕊五味子*S. propinqua*	23		2		
阿里山五味子*S. arisanensis*	4	8			
S. nigra			1		
球蕊五味子*S. sphaerandra*	1				
小花五味子*S. micrantha*	3				
黑老虎*Kadsura coccinea*	16	7		1	
风庆南五味子*K. interior*	9	7			
异形南五味子*K. heteroclita*	7	11		1	1
长梗南五味子*K. longipedunculata*	18	6		2	
日本南五味子*K. japonica*	14				
K. matsudai	8	1			
狭叶南五味子*K. angustifolia*	7			1	
仁昌南五味子*K. renchangiana*	4				
菲律宾五味子*K. philippinensis*	4	3			

只出现在C-14或C-1位, 而亚甲二氧基则在C-12(13)或C-2(3)。八元环的取代主要发生在C-6, 9位的成酯取代(酯基多位当归酸酯、苯甲酸酯、乙酸酯等), 羟基多在C-6, 7位取代。化合物134–138是联苯环辛烯类中较特殊的一类, 特征为在八元环上跨氧桥, 这一类化合物多从南五味子科中分离得到, 仅有一个从合蕊五味子中得到。从总体上来看, 联苯环辛烯类木脂素在五味子属和南五味子属植物的果实和藤茎中较平均分布, 可以被认为是五味子科植物的特征性化学成分; 芳基四氢萘类和四氢呋喃类木脂素绝大多数存在于五味子属植物的藤茎中; 二芳基丁烷类较多地存在于五味子属, 而螺苯骈呋喃型联苯环辛烯类木脂素则多存在于南五味子属植物的藤茎中, 可以看作是南五味子属植物的特有化学成分, 这类成分具有重要的分类学意义。值得提出的是, 五味子科中分离得到的42个螺苯骈呋喃型联苯环辛烯类木脂素中, 除11个化合物来自五味子属红花五味子、阿里山五味子, 其他均从南五味子属分离得到, 由此可以推测红花五味子和阿里山五味子及其近缘种是五味子属与南五味子属之间的过渡类群, 这一点还需要其他证据来佐证。上述五味子科植物木脂素的分布规律提示, 在演化程度上, 五味子属较南五味子属更原始, 因而作者支持Smith (1947)的观点, 将五味子属放在南五味子属之前。

2.2 五味子植物中的三萜及其分类学意义

五味子科植物中分离鉴定出的另一大类成分为三萜, 分离得到100余种。三萜类化合物的结构复杂多样, 新颖独特, 根据A环是否开环以及三萜各环的碳原子数将骨架分为5种类型: I. 6/6/6/5或6/6/5/6型环菠萝蜜烷三萜(A环闭环)(cycloartanone triterpenes, A-ring close; 图7; 表7); II. 6/6/5或者6/5/6型环菠萝蜜烷型三萜(A环开环)(cycloartanone triterpenes, A-ring open; 图8; 表8); III. 7/6/6/5或者7/7/6/5型三萜(7/6/6/5 or 7/7/6/5 type triterpenes; 图9; 表9); IV. 7/7/5/6型三萜内酯(7/7/5/6 type triterpene lactones; 图10; 表10); V. 类三萜内酯(nor-triterpene lactones; 图11; 表11)。

从生源途径上来说, 羊毛甾烷型四环三萜是其他几类三萜的生物合成前体, 取代基团多为当归酸酯侧链或六元内酯环, 一些化合物则在A环3, 4开环而形成二酸或内酯酸。7/7/5/6型三萜内酯应该是从7/7/6/5型三萜内酯衍化而来的, 属较进化的化学成分; 近期研究发现一类结构新颖的类三萜内酯, 成环复杂, 且结构高度氧化, 理应属于更进化的化学成分, 此类类三萜内酯目前只出现在五味子科植物中, 具有较重要的分类学意义(图12; 表12)。

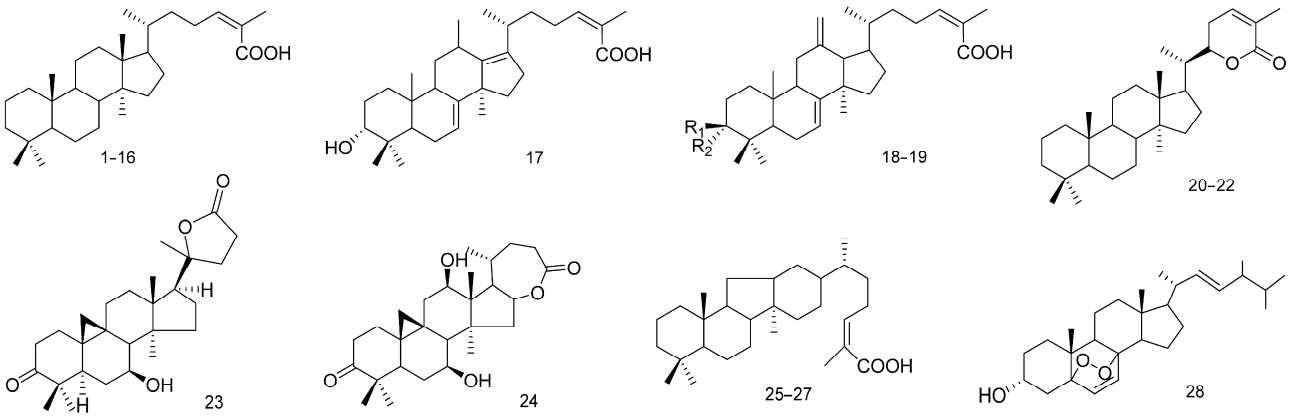


图7 五味子科植物中环菠萝蜜烷型三萜(A环闭环)的结构

Fig. 7. Structures of cycloartanone triterpenes (A-ring close) from Schisandraceae.

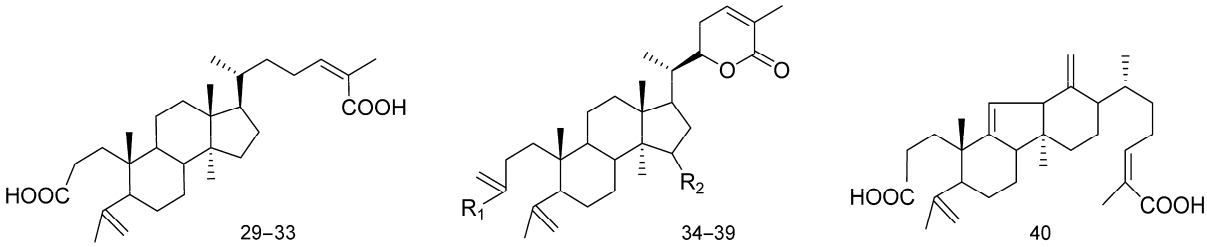


图8 五味子科植物中菠萝蜜烷型三萜的结构

Fig. 8. Structures of cycloartanone triterpenes (A-ring open) from Schisandraceae.

三萜类成分在五味子科植物中的分布同样显示出了一定的规律性: 绝大多数三萜类成分都从五味子科药用植物的藤茎中分离得到, 而在果实中分布很少, 比如只在华中五味子的果实中发现了两个三萜化合物。羊毛甾烷型四环三萜在五味子属和南五味子属均有分布。而7/6/6/5, 7/7/6/5型两大类三萜是四环三萜中较6/6/6/5三萜更进化的成分, 此两类内酯大多数存在于南五味子属。目前为止, 有7个7/7/6/5型三萜内酯从合蕊五味子和翼梗五味子*S. henryi* Clarke中分离得到, 其他都从南五味子属植物中分离得到, 这点提示我们或许合蕊五味子和翼梗五味子及其变种是由北五味子属向南五味子属进化的过渡类群, 但是这需要更多的证据来支持。显然, 7/7/5/6型三萜内酯从7/7/6/5型三萜内酯进化而来, 属于更进化的化学状态, 目前这类成分只在南五味子植物中发现, 从上述两点来看, 南五味子属是较五味子属更为进化的类群; 然而, 近年来的研究发现, 从五味子属的小花五味子和狭叶五味子中分离得到了20个类三萜内酯, 这些类三萜内酯成环复杂, 且高度氧化, 属于更为进化的化学状态, 此研究结果向我们提示五味子属的小花五味子和狭叶五味子也许是较为进化的两个种, 但这仅仅是就目前的研究结果进行的推测, 更多的三萜类成分有待于在五味子属植物中发现。虽然三萜类成分在化学结构上的多样性和复杂性很难给出南五味子属是五味子科中较五味子属更为进化的类群这样的定论, 但是仍支持五味子属和南五味子属的亲缘关系较近, 对于该科植物的化学分类同样具有重要性。

3 传统疗效

在我国民间, 五味子属植物中作为药用的共有14种4变种, 传统上, 本属很多植物以果实入药, 具有滋补强壮、宁心安神、止咳化痰之功能, 如《中华人民共和国药典》收载的五味子*Schisandra chinensis* Baill.和华中五味子*S. sphenanthera* Rehd. & Wils.的果实, 在民间五味子属其他种的果实多用

表7 五味子科植物中环菠萝蜜烷型三萜(A环闭环)
Table 7 Cycloartanone triterpenes (A-ring close) from Schisandraceae

序号 No.	化合物名称 Compound	结构[1] Structure[1]	来源植物[2] Plant source[2]	文献 Reference
1	schisandronic acid	3-oxo; 9,19-cyclo; 24(Z)	*Schisandra nigra* (s) *Schisandra* sp. (s) 华中五味子*S. sphenanthera* (s) 中间五味子*S. propinqua* var. *intermedia* (s) 五味子*S. chinensis* (s) *Kadsura* sp. (s) 小花五味子*S. micrantha* (s) 异形五味子*Kadsura heteroclita* (s) 合蕊五味子*S. propinqua* (s) 翼梗五味子*S. henryi* (s)	Takahashi & Takani, 1975 Liu & Huang, 1988a Chen et al., 1987 Li et al., 1995 Liu et al., 1990 Liu & Huang, 1991 Li et al., 2003a Chen et al., 2001d Chen et al., 2003 Wang et al., 2006b
2	heteroclic acid	3-oxo; 9,19-cyclo; 24(Z) 22-OAc	异形五味子*K. heteroclita* (s)	Wang et al., 2006b
3	schizandrolic acid	3-βOH; 9,19-cyclo; 24(Z)	*S. nigra* (s)	Takahashi et al., 1975
4	isoschizandrolic acid	3-αOH; 9,19-cyclo; 24(Z)	中间五味子*S. propinqua* var. *intermedia* (s) *Kadsura* sp. (s)	Li et al., 1995 Liu & Huang, 1988
5	anwuweisonic acid	3-oxo, R_1=CH3, R_2=H	合蕊五味子*S. propinqua* (s)	Liu et al., 1988a
6	epianwuweizic acid	3-βOH, 24(Z)-Δ^8	长梗南五味子*K. longipedunculata* (s) 狭叶南五味子*K. angustifolia* (s)	Liu et al., 1991 Chen et al., 2002b
7	anwuweizic acid	3-αOH, 24(Z)-Δ^8	华中五味子*S. sphenanthera* (f, s) 狭叶南五味子*K. angustifolia* (s)	Liu & Huang, 1984a Chen et al., 2002b
8	coccinic acid	3-oxo, 24(Z)-$\Delta^{9(11)}$	黑老虎*K. coccinea* (s) 滇藏五味子*S. neglecta* A. C. Smith (s)	Li & Xue, 1986b Ma et al., 2002
9	iso-anwuweizic acid	3-αOH, 24(Z)-$\Delta^{9(11)}$	异形南五味子*K. heteroclita* (s)	Dai et al., 1990
10	(24Z)-3-oxo-12α-acetoxyl anosta-8,24-dien-26-oic acid	3-oxo, 12-αOAc, 24(Z)-Δ^8	长梗南五味子*K. longipedunculata* (s) 小花五味子*S. micrantha* (s)	Li et al., 1989c Li et al., 2003a
11	(24Z)-3-oxo-12α-hydroxyl anosta-8,24-dien-26-oic acid	3-oxo, 12-αOH, 24(Z)-Δ^8	长梗南五味子*K. longipedunculata* (s)	Li et al., 1989c
12	12β-acetoxycoccinic acid	3-oxo, 12-βOAc, 24(Z)-$\Delta^{9(11)}$	异形南五味子 *K. heteroclita* (s)	Li et al., 1989b
13	12β-hydroxycoccinic acid	3-oxo, 12-βOH, 24(Z)-$\Delta^{9(11)}$	异形南五味子*K. heteroclita* (s)	Li et al., 1989b
14	12α-acetoxycoccinic acid	3-oxo, 12-αOAc, 24(Z)-$\Delta^{9(11)}$	异形南五味子*K. heteroclita* (s)	Li et al., 1989b
15	12α-hydroxycoccinic acid	3-oxo, 12-αOH, 24(Z)-$\Delta^{9(11)}$	异形南五味子*K. heteroclita* (s)	Li et al., 1989b
16	schisanhenric acid	3-oxo, 22-OAc, 24(E)-$\Delta^{9(11)}$	翼梗五味子*S. henryi* (s)	Li et al., 1989b
17	ananosic acid A		中泰南五味子 *K. ananosma* (s)	Chen et al., 2001e
18	ananosic acid B	R_1=H, R_2=CH_3COO–	中泰南五味子*K. ananosma* (s)	Chen et al., 2004b
19	ananosic acid C	R_1=R_2=O	中泰南五味子*K. ananosma* (s)	Chen et al., 2004b
20	kadsulactone	3-oxo, 9,19-cyclo	长梗南五味子*K. longipedunculata* (s) *Kadsura* sp. (s)	You et al., 1997 Ran et al., 1991
21	schisanlactone D	3-oxo, $\Delta^{9(11)}$	*Schisandra* sp. (f, s)	Liu & Huang, 1984b
22	schisanol	3-βOH, $\Delta^{9(11)}$	华中五味子*S. sphenanthera* (f, s)	Yue et al., 1994
23	schisanterpene B		合蕊五味子*S. propinqua* (s)	Xu et al., 2006
24	lancifodilactone H		狭叶五味子*S. lancifolia* A. C. Smith (s)	Xiao et al., 2006b
25	neokadsuranic acid A	3-oxo; (24Z)-$\Delta^{9(11),13(18)}$	异形南五味子*K. heteroclita* (s)	Kangouri et al., 1989
26	neokadsuranic acid B	3-oxo; (24Z)-$\Delta^{8,13(18)}$	长梗南五味子*K. longipedunculata* (s)	Li et al., 1989c
27	neokadsuranic acid C	3-oxo; (24Z)-Δ^8, 13-βOH	长梗南五味子*K. longipedunculata* (s)	Li et al., 1989c
28	ergosterol peroxide		滇藏五味子*S. neglecta* (s)	Ma et al., 2002

1) Ac =

2) f, 果实; s, 茎。f, fruits; s, stems.

表8 五味子科植物中环菠萝蜜烷型三萜(A环裂环)
Table 8 Cycloartanone triterpenes (A-ring open) from Schisandraceae

序号 No.	化合物名称 Compound	结构[1] Structure[1]	来源植物[2] Plant source[2]	文献 Reference
29	manwuweizic acid	(24Z)-Δ^8	合蕊五味子*Schisandra propinqua* (s) 异形南五味子*Kadsura heteroclita* (s)	Liu et al., 1988a Chen et al., 2001d
30	kadsuric acid	(24Z)-$\Delta^{9(11)}$	翼梗五味子*S. henryi* (s) 黑老虎*K. coccinea* (s) 滇藏五味子*S. neglecta* (s) 小花五味子*S. micrantha* (s)	Chen et al., 2003 Li & Xue, 1986b Ma et al., 2002 Li et al., 2003a
31	changnanic acid	9,19-cyclo, (24Z)-Δ^6	长梗南五味子*K. longipedunculata* (s) 异形南五味子*K. heteroclita* (s)	Liu & Huang, 1991 Wang et al., 2006b
32	nigranoic acid	R_1=R_2=CH_2, 9,19-cyclo, (24Z)-	球蕊五味子*S. sphaerandra* (s) 翼梗五味子*S. henryi* (s) 狭叶五味子*S. lancifolia* (s) 合蕊五味子*S. propinqua* (s) 异形南五味子*K. heteroclita* (s)	Sun et al., 1996 Chen et al., 2003 Xiao et al., 2006b Chen et al., 2001d Wang et al., 2006b
33	lancifoic acid A	R_1=OH, R_2=CH_3, 9,19-cyclo, (24Z)	狭叶五味子*S. lancifolia* (s)	Xiao et al., 2006b
34	heteroclitalactones A	R_1=OH, R_2=OAc, 9,19-cyclo	异形南五味子*K. heteroclita* (s)	Wang et al., 2006b
35	heteroclitalactones B	R_1= OCH_3, R_2=OAc, 9,19-cyclo	异形南五味子*K. heteroclita* (s)	Wang et al., 2006b
36	heteroclitalactones C	R_1=EtO, R_2=OAc, 9,19-cyclo	异形南五味子*K. heteroclita* (s)	Wang et al., 2006b
37	heteroclitalactones F	R_1= OCH_3, R_2=H, 9,19-cyclo	异形南五味子*K. heteroclita* (s)	Wang et al., 2006b
38	schisanlactone E	R_1=OH, R_2=H, 9,19-cyclo	长梗南五味子*K. longipedunculata* (s) 异形南五味子*K. heteroclita* (s)	Liu & Huang, 1991 Wang et al., 2006b
39	schisanlactone F	R_1=OH, R_2=H, 9,19-cyclo,Δ^8	长梗南五味子*K. longipedunculata* (s)	Liu & Pan, 1991
40	seco-neokadsuranic acid A	(24Z)-$\Delta^{8,13(18)}$	异形南五味子*K. heteroclita* (s)	Li et al., 1989a

1) Ac = $-\overset{O}{\overset{\|}{C}}-CH_3$
2) f, 果实; s, 茎。f, fruits; s, stems.

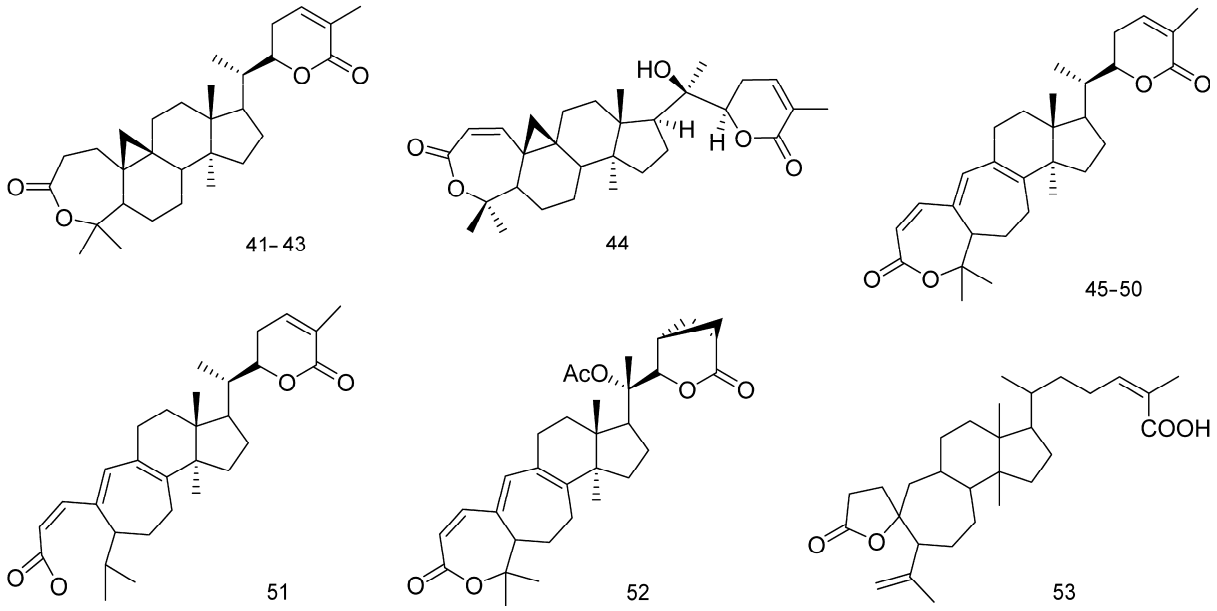
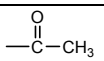


图9 五味子科植物中7/6/6/5或者7/7/6/5三萜的结构
Fig. 9. Structures of 7/6/6/5 or 7/7/6/5 type triterpenes from Schisandraceae.

表9 五味子科植物中7/6/6/5或者7/7/6/5三萜
Table 9 7/6/6/5 or 7/7/6/5 type triterpenes from Schisandraceae

序号 No.	化合物名称 Compound	结构[1] Structure[1]	来源植物[2] Plant source[2]	文献 Reference
41	kadsudilactone	9,19-cyclo	*Kadsura* sp.	Ran et al., 1991
42	schisanlactone B	9,19-cyclo, Δ^1	*Schisandra* sp. (s)	Liu et al., 1983a
			翼梗五味子*S. henryi* (s)	Chen et al., 2003
			合蕊五味子*S. propinqua* (s)	Chen et al., 2001b
			异形南五味子*K. heteroclita* (s)	Wang et al., 2006b
43	kadsulactone A	6-βOH, 9,19-cyclo, Δ^1	*K. lancilimba* How. (s)	Chen et al., 1999
44	kadsuphilactone B	Δ1, 20-OH	菲律宾五味子*K. philippinensis* (s)	Shen et al., 2005b
45	heteroclitalactones D	12-OAc, 20-H	异形南五味子*K. heteroclita* (s)	Wang et al., 2006b
46	heteroclitalactones E	12-OAc, 20-OH, $\Delta^{6,7}$	异形南五味子*K. heteroclita* (s)	Wang et al., 2006b
47	schisanlactone A	$\Delta^{1,8,10\,(19)}$	*Schisandra* sp. (s)	Liu et al., 1983b
			长梗南五味子*K. longipedunculata* (s)	Sun et al., 2006
			合蕊五味子*S. propinqua* (s)	Chen et al., 2001b
48	schisanlactone C	$\Delta^{1,8,10\,(19)}$, 20-OH	*Schisandra* sp. (f, s)	Liu & Ma, 1984b
			合蕊五味子*S. propinqua* (s)	Kuo et al., 1999
49	lancilactone A	6-βOH, $\Delta^{1,8,10\,(19)}$	*K. lancilimba* (s)	Chen et al., 1999
50	lancilactone B	$\Delta^{1,6,8,10\,(19)}$	*K. lancilimba* (s)	Chen et al., 1999
51	lancilactone C		*K. lancilimba* (s)	Chen et al., 1999
52	schiprolactone A		合蕊五味子*S. propinqua* (s)	Chen et al., 2001b
			翼梗五味子*S. henryi* (s)	Chen et al., 2003
53	schisanterpene A		合蕊五味子*S. propinqua* (s)	Zhou et al., 2002
			滇五味子*S. henryi* Clarke var. *yunnanensis* A. C. Smith (s)	Li et al., 2004b

1) Ac = 
2) f, 果实; s, 茎。f, fruits; s, stems.

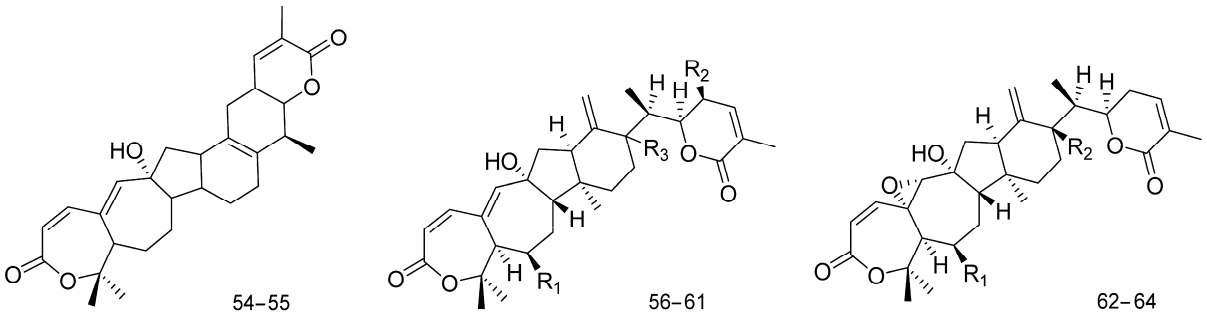


图10 五味子科植物中7/7/5/6型三萜内酯的结构
Fig. 10. Structures of 7/7/5/6 type triterpene lactones from Schisandraceae.

表10 五味子科植物中7/7/5/6型三萜内酯
Table 10 7/7/5/6 type triterpene lactones from Schisandraceae

序号 No.	化合物名称 Compound	结构 Structure	来源植物[1] Plant source[1]	文献 Reference
54	kadlongilactone A		长梗南五味子*Kadsura longipedunculata* (s)	Pu et al., 2005
55	kadlongilactone B		长梗南五味子*K. longipedunculata* (s)	Pu et al., 2005
56	longipedlactone A	R_1=H, R_2=H, $\Delta^{10,19}$	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
57	longipedlactone E	R_1=H, Δ^{16}, R_2=OH, $\Delta^{10,19}$	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
58	longipedlactone F	R_1=OH, Δ^{16}, R_2=H, $\Delta^{10,19}$	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
59	longipedlactone B	R_1=H, R_2=H, R_3=H, $\Delta^{10,19}$	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
60	longipedlactone C	R_1=H, R_2=H, R_3=OH,$\Delta^{10,19}$	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
61	longipedlactone H	R_1=OH, R_2=H, R_3=H,$\Delta^{10,19}$	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
62	longipedlactone D	R_1=H,(10,19 a trisubstituted epoxide)	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
63	longipedlactone G	R_1=OH, Δ^{16}	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006
64	longipedlactone I	R_1=R_2=OH	长梗南五味子*K. longipedunculata* (s)	Pu et al., 2006

1) f, 果实; s, 茎。f, fruits; s, stems.

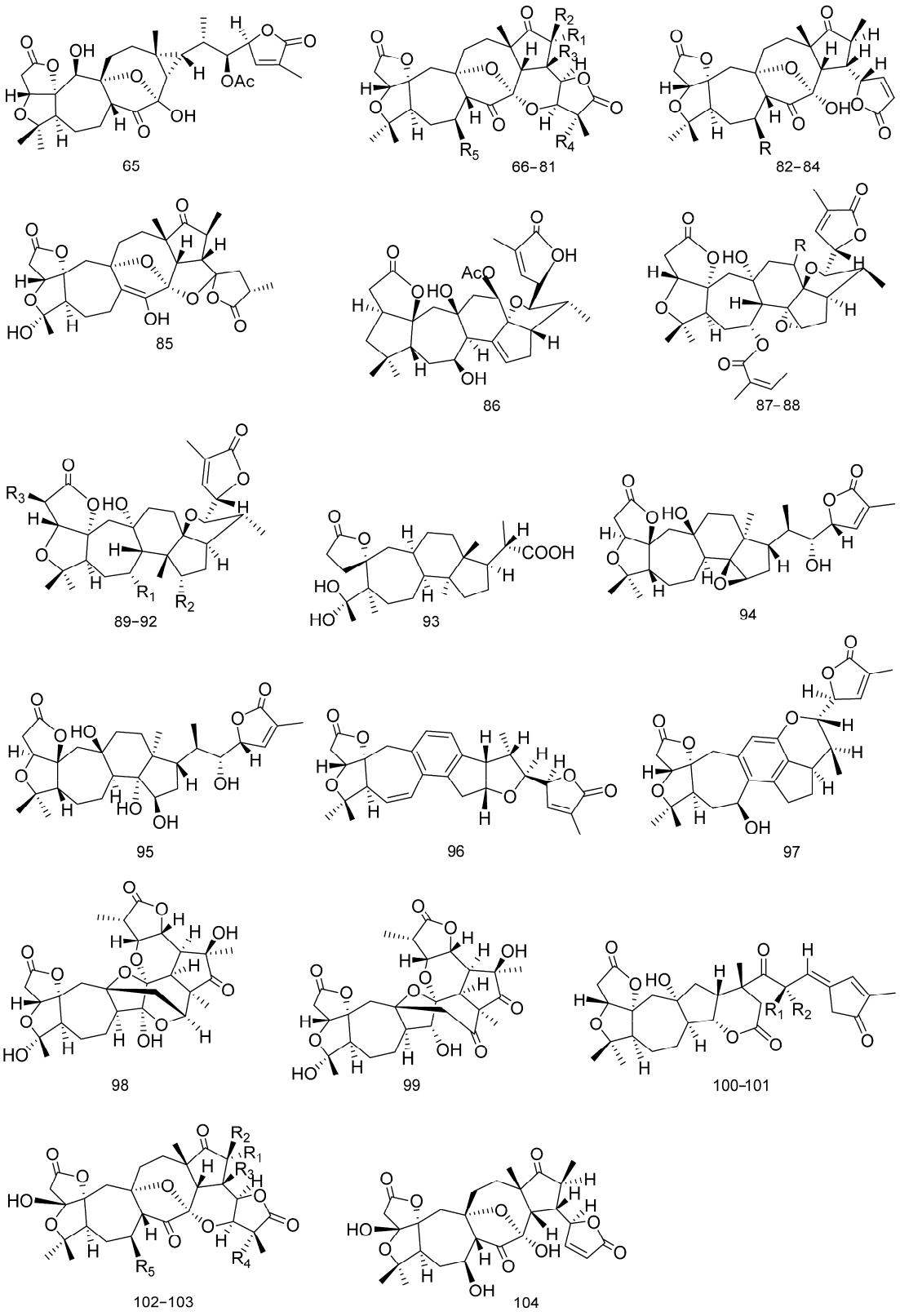


图11 五味子科植物中类三萜内酯的结构
Fig. 11. Structures of nor-triterpene lactones from Schisandraceae.

表11 五味子科植物中类三萜内酯
Table 11 Nor-triterpene lactones from Schisandraceae

序号 No.	化合物名称 Compound	结构[1] Structure[1]	来源植物[2] Plant source[2]	文献 Reference
65	pre-schisanartanin		五味子*Schisandra chinensis* (s)	Huang et al., 2007a
66	henridilactone A	R_1=OH, R_2=CH_3, R_3=H, R_4=H, Δ^7	滇五味子*S. henryi* var. *yunnanensis* (s)	Li et al., 2004b
67	henridilactone B	R_1=OH, R_2=CH_3, R_3=OH, R_4=H, Δ^7	滇五味子*S. henryi* var. *yunnanensis* (s)	Li et al., 2004b
68	henridilactone C	R_1=CH_3, R_2=H, R_3=H, R_4=H, Δ^7	滇五味子*S. henryi* var. *yunnanensis* (s)	Li et al., 2004b
69	lancifodilactone D	R_1=H, R_2=CH_3, R_3=H, R_4=H, Δ^7	狭叶五味子*S. lancifolia* (s)	Li et al., 2004b
70	lancifodilactone B	R_1=H, R_2=CH_3, R_3=H, R_4=OH, 7,8-cyclo	狭叶五味子*S. lancifolia* (s)	Li et al., 2004b
71	lancifodilactone N	R_1=H, R_2=CH_3, R_3=H, R_4=OH, Δ^7	狭叶五味子*S. lancifolia* (s)	Xiao et al., 2006a
72	micrandilactone F	R_1=OH, R_2= CH_3, R_3=H, R_4=H, Δ^7	小花五味子*S. micrantha* (s)	Li et al., 2005a
73	micrandilactone A	7-αOH, 20-αCH3, 20-βOH, 22-αOH, R_5=OH	小花五味子*S. micrantha* (s)	Li et al., 2003c
74	henridilactone D	R_1=CH_3, R_2=H, R_3=H, R_4=H, R_5=OH	滇五味子*S. henryi* var. *yunnanensis* (s)	Li et al., 2004b
75	lancifodilactone C	R_1=H, R_2=CH_3, R_3=H, R_4=H, R_5=OH	狭叶五味子*S. lancifolia* (s)	Li et al., 2004c
76	lancifodilactone E	R_1=CH_3, R_2=H, R_3=H, R_4=OH, R_5=OH	狭叶五味子*S. lancifolia* (s)	Li et al., 2004c
77	lancifodilactone L	R_1=H, R_2=CH_3, R_3=H, R_4=OH, R_5=OH	狭叶五味子*S. lancifolia* (s)	Xiao et al., 2006a
78	micrandilactone D	R_1=OH, R_2=CH_3, R_3=H, R_4=H, R_5=OH	小花五味子*S. micrantha* (s)	Li et al., 2005a
79	micrandilactone E	R_1=CH_3, R_2=OH, R_3=H, R_4=H, R_5=OH	小花五味子*S. micrantha* (s)	Li et al., 2005a
80	micrandilactone G	R_1=H, R_2=CH_3, R_3=H, R_4=H, R_5=OH	小花五味子*S. micrantha* (s)	Li et al., 2005a
81	lancifodilactone M	R_2=CH_3, $\Delta^{20(22)}$, R_4=H, R_5=OH	狭叶五味子*S. lancifolia* (s)	Xiao et al., 2006a
82	lancifodilactone I	R=OH	狭叶五味子*S. lancifolia* (s)	Xiao et al., 2006a
83	lancifodilactone J	R=OAc	狭叶五味子*S. lancifolia* (s)	Xiao et al., 2006a
84	lancifodilactone K	Δ^7	狭叶五味子*S. lancifolia* (s)	Xiao et al., 2006a
85	lancifodilactone G		狭叶五味子*S. lancifolia* (s)	Xiao et al., 2005b
86	lancifodilactone A		狭叶五味子*S. lancifolia* (s)	Li et al., 2003b
87	wuweizidilactones A	R=O	五味子*S. chinensis* (s)	Huang et al., 2007c
88	wuweizidilactones B	R=α-OAc	五味子*S. chinensis* (s)	Huang et al., 2007c
89	wuweizidilactones C	R_1=OAc, R_2=OH, R_3=H	五味子*S. chinensis* (s)	Huang et al., 2007c
90	wuweizidilactones D	R_1=H, R_2=OH, R_3=H	五味子*S. chinensis* (s)	Huang et al., 2007c
91	wuweizidilactones E	R_1=H, R_2=OAc, R_3=H	五味子*S. chinensis* (s)	Huang et al., 2007c
92	wuweizidilactones F	R_1=H, R_2=OAc, R_3=OH	五味子*S. chinensis* (s)	Huang et al., 2007c
93	lancifodilactone F		狭叶五味子*S. lancifolia* (s)	Xiao et al., 2005a
94	micrandilactone B		小花五味子*S. micrantha* (s)	Li et al., 2005b
95	micrandilactone C		小花五味子*S. micrantha* (s)	Li et al., 2005b
96	rubriflordilactones B		红花五味子*S. rubriflora* (s)	Xiao et al., 2006c
97	rubriflordilactones A		红花五味子*S. rubriflora* (s)	Xiao et al., 2006c
98	sphenadilactones A		华中五味子*S. sphenanthera* (s)	Xiao et al., 2006d
99	sphenadilactones B		华中五味子*S. sphenanthera* (s)	Xiao et al., 2006d
100	schintrilactone A	R_1=CH_3, R_2=H	五味子*S. chinensis* (s)	Huang et al., 2007b
101	schintrilactone B	R_1=H, R_2=CH_3	五味子*S. chinensis* (s)	Huang et al., 2007b
102	schindilactone A	R_1=H, R_2=CH_3, R_3=H, R_4=H, Δ^7	五味子*S. chinensis* (s)	Huang et al., 2007a
103	schindilactone B	R_1=CH_3, R_2=R_3=R_4=H, Δ^7	五味子*S. chinensis* (s)	Huang et al., 2007a
104	schindilactone C		五味子*S. chinensis* (s)	Huang et al., 2007a

1) Ac = $-\overset{O}{\overset{\|}{C}}-CH_3$

2) f, 果实; s, 茎。f, fruits; s, stems.

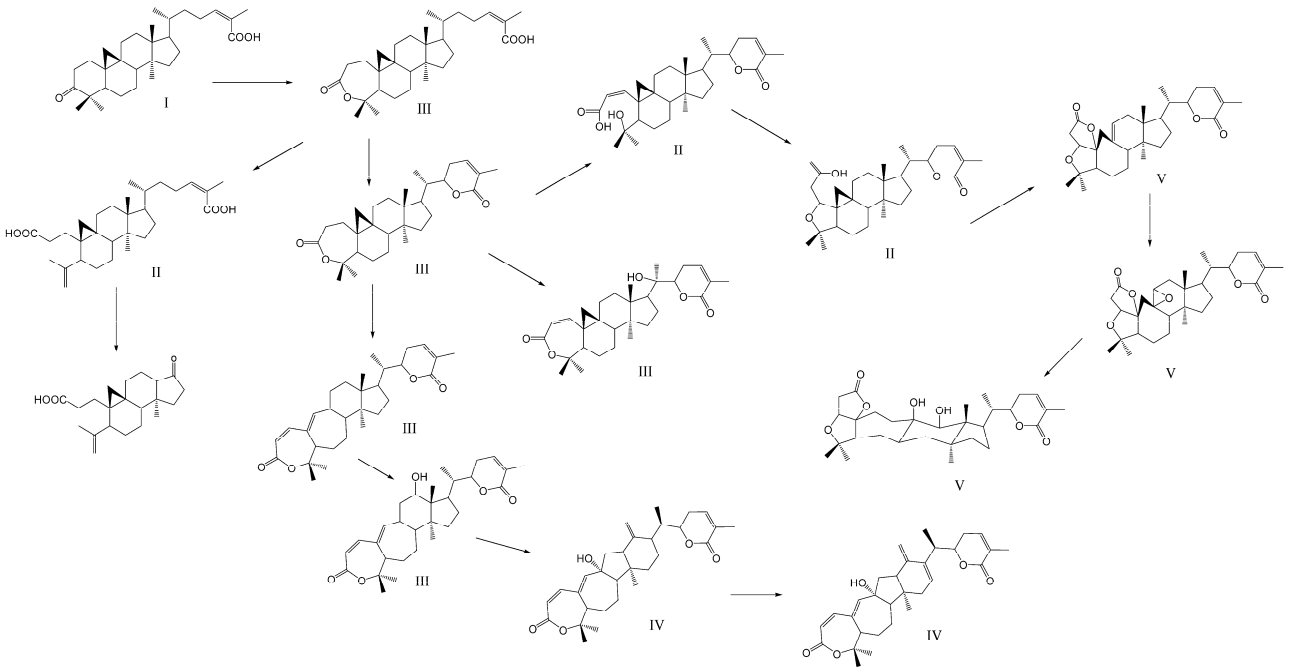


图12 五味子科植物中各类三萜成分之间的演化关系(Li et al., 2003a; Shen et al., 2005a; Pu et al., 2006; Huang et al., 2007a, b)
Fig. 12. Proposed biogenetic relationships between different triterpene types in Schisandraceae (Li et al., 2003a; Shen et al., 2005a; Pu et al., 2006; Huang et al., 2007a, b).

表12 三萜类化合物在五味子科药用植物中的分布
Table 12 Distribution of triterpenes in family Schisandraceae

种 Species	三萜类化合物 Triterpenes				
	I 环菠萝蜜烷型三萜(A环闭环) Cycloartanone triterpenes (A-ring A close)	II 菠萝蜜烷型三萜(A环开环) Cycloartanone triterpenes (A-ring open)	III 7/6/6/5或者7/7/6/5三萜 7/6/6/5 or 7/7/6/5 type triterpenes	IV 7/7/5/6型三萜内酯 7/7/5/6 type triterpene lactones	V 类三萜内酯 Nor-triterpene lactones
五味子*Schisandra chinensis* (s)	1				12
华中五味子*S. sphenanthera* (s)	3				2
红花五味子*S. rubriflora*					2
翼梗五味子*S. henryi*	2	2	2		
滇五味子*S. henryi* var. *yunnanensis* (s)			1		4
合蕊五味子*S. propinqua*	3	2	5		
S. nigra	2				
小花五味子*S. micrantha* (s)	2	1			7
狭叶五味子*S. lancifolia* (s)	1	2			13
黑老虎*Kadsura coccinea*	1	1			
异形南五味子*K. heteroclita*	8	9	3		
长梗南五味子*K. longipedunculata*	6	3	1	11	
K. lancilimba			4		
狭叶南五味子*K. angustifolia*	2				
菲律宾五味子*K. philippinensis*			1		

来作为五味子的代用品, 主要用来治疗肺虚久咳, 失眠多梦, 自汗盗汗等症。在南五味子属中8种具有药用价值, 该属大多植物多为地方习用药材, 以藤茎入药, 通常称风藤、紫金皮等, 具有活血通络、祛风除湿的作用。如凤庆南五味子在云南作为鸡血藤治疗妇科疼痛, 异形南五味子在广东、广西作为海风藤治疗风湿痹痛, 其他南五味子属植物在民间也广泛用于治疗各种痛症, 在中国西南分布最为集中的是长梗南五味子和黑老虎, 用作治疗跌打损伤、风湿骨痛、胃病、月经不调等症。此外, 五味子属药用植物的藤茎通常称血藤, 如翼梗五味子、小花五味子, 与南五味子属植物藤茎药效相似。

4 现代药理/生理活性研究及主要物质基础

4.1 现代药理活性研究及主要物质基础

4.1.1 镇静催眠作用 五味子水/乙醇提取物以及其主要有效成分五味子醇甲等对中枢神经有显著的镇静、催眠、抗惊厥作用。研究表明五味子乙醇提取液、北五味子水提取物均可使小鼠自主活动明显减少(霍艳双等, 2005), 对抗中枢兴奋药苯丙胺对自主活动的兴奋作用, 可明显延长阈上睡眠剂量戊巴比妥钠致小鼠睡眠时间。五味子仁乙醇提取物中主要有效成分之一五味子醇甲能明显加强利血平及戊巴比妥钠对自主活动的抑制作用, 对抗咖啡因、苯丙胺对自主活动的兴奋作用, 抑制小鼠由电刺激或长期单居引起的激怒行为。此外, 五味子醇甲还能对抗MES、戊巴唑、瘀碱及北美黄连碱的强直惊厥(郭冷秋等, 2006)。

4.1.2 止咳祛痰 用五味子及其乙醚提取物, 无论灌胃给药或腹腔注射, 对氨水引咳的小鼠均有止咳作用, 小鼠酚红试验表明, 五味子有祛痰效果, 从五味子中分离得到的两种结晶物均有明显镇咳作用(何来英等, 2004)。五味子水煎液不仅使小鼠气管腺内花生素(PNA)和双花扁豆素(DBA)结合的中性黏多糖明显减少, 而且使酸性黏多糖也相应减少, 形态和组织化学检查结果证实五味子的酸性成分有祛痰作用(郭冷秋等, 2006)。上述研究为五味子果实止咳化痰的传统疗效提供了科学合理的解释。

4.1.3 保肝作用 五味子保肝作用的主要物质基础为联苯环辛烯类木脂素。研究发现, 五仁醇等能降低四氯化碳(CCl_4)或其他化学物质如硫代乙酰胺(TAA)、扑热息痛引起的实验动物SGPT升高, 减少肝内GSH含量的下降, 促进肝细胞蛋白质的合成, 促进线粒体恢复和再生(卢华, 刘耕陶, 1990)。五味子对大鼠肝微粒体细胞色素P450具有明显的诱导作用, 其保肝作用可能与诱导肝药酶加快某些有毒物质的代谢有关(张锦楠等, 2002)。五仁醇的主要成分甲素、乙素、丙素、醇乙、五酚均能显著提高肝微粒体细胞色素P450、NADPH-细胞色素P450还原酶、氨基比林脱甲基酶及苯并芘羟化酶活性, 微粒体蛋白亦显著增加, 还能促进肝糖元的合成, 增加肝细胞的能量储备(刘耕陶, 1987), 且发现乙素和醇乙主要诱导滑面内质网的细胞色素P450B2部分, 属苯巴比妥型的P450诱导剂(刘耕陶, 1987, 1988)。从*K. matsudai* Hayata和阿里山五味子分得的联苯环辛二烯木脂素(Gomisin K_3, kadsurarin, Schizanrins B、C、D、E, taiwanschirin D等)在抗HBsAg、HBeAg试验中显示出不同程度的抗肝炎活性(Li et al., 2000; Wu et al., 2003; Kuo et al., 2005a)。阿里山五味子来源的联苯环辛烯木脂素gomisin B, G and (+)-gomisin K_3通过抗HbsAg、HBeAg抗原发挥抗肝炎作用(Wu et al., 2003)。

4.1.4 抗肿瘤 五味子乙素对小鼠腹水型肝癌细胞、小鼠S180-V癌细胞和人胚肺成纤维细胞DNA合成具有明显抑制作用, 还可抑制腹水型肝癌细胞的核蛋白和ATP代谢的动态过程, 表明五味子乙素对癌细胞的增殖和代谢均有抑制作用(刘力生等, 1984a)。Kadsulignan C、D、H、K, epienshicine, wulignanA1、A2、epiwulignan A1、epischisandrone、epienshicine及changnanic acid、schisanlactone E体外对P388细胞均有不同程度的抑制作用(Liu et al., 1988)。体外实验证实, 五酯酮A、B, 五内酯E、F, 长南酸均有显著抑制小鼠白血病细胞株P388增殖的作用(Li et al., 1989c, You et al., 1997)。Schisarisanrin C对KB、Colo-250、HEPA-3B和HEPA等肿瘤细胞株有细胞毒作用(Chen et al., 1996)。Gomisin A能抑制3′-甲基-4二甲基氨基偶氮苯(3′-MeDAB)引起的大鼠肝癌前损伤及12-O-十四烷酰基佛波醇-13-己酯促进7,12-二甲基并蒽诱导的小鼠皮肤癌, Manwuweizic acid具有抑制小鼠Lewis肺癌, 脑瘤-22和肝硬化的作用(Liu et al., 1988a)。从阿里山五味子中得到的tanwanschirin C和schizarin A显示了对Hepa-3B肿瘤细胞的细胞毒性作用, 并且认为6位

取代与活性间存在构效关系(Kuo et al., 1999)。从合蕊五味子中分得的三萜酸nigranoic acid和manwuweizic acid, 在体外对人蜕膜细胞及大鼠黄体细胞具有很强的细胞毒性活性(Chen et al., 2001d)。从翼梗五味子茎分得三萜类化合物schiprolactone A、schisanlactone B、nigranoic acid和schisandronic acid, 在体外对Leukemia肿瘤细胞株显示活性, schisanlactone B和schisandronic acid对Leukemia细胞株显示了中等强度的细胞毒活性(Chen et al., 2003)。从中泰南五味子茎分离得到两个三萜酸ananosic acids B、C, 对CCRF-CEM和HeLa肿瘤细胞表现出细胞毒性(Chen et al., 2004b)。从凤庆南五味子分得木脂素interiotherins C、interiotherins D、interiorin、heteroclitin F、neokadsuranin、heteroclitin D、kadsurin、gomisin A、schisandrin C、interiotherin A、angeloylgomisin R、gomisin G、interiotherin B和gomisin C, 可以抑制EB病毒对Raji细胞的感染, 可能作为抗肿瘤预防用药(Chen et al., 2002a)。Schisandrin B对P-糖蛋白有很强的抑制作用, 可以逆转P-糖蛋白过表达介导的肿瘤细胞多药耐药现象, 从而发挥抗肿瘤作用, 有望成为一种新的抗肿瘤制剂(Pan et al., 2005)。从长梗南五味子藤茎中分离得到的三萜化合物 kadlongilactones A和B在体外对人肿瘤细胞株K562增殖有明显的抑制作用(Pu et al., 2005), 三萜化合物longipedlactone A、B、C、F和H在体外对A549、HT-29和K562具有明显的细胞毒性(Pu et al., 2006)。Gomisin G体外对肿瘤细胞株Leukemia 和Hela显示了很强的细胞毒活性(Chen et al., 2005b)。本课题组从铁箍散藤茎中分离得到的木脂素propinquanin B体外对肿瘤细胞株HL-60和Hep-G2显示了强细胞毒活性(Xu et al., 2006)。Lancifodilactone G和Lancifodilactone F在体外对C8166细胞显示温和的细胞毒活性(Xiao et al., 2005a, b)。五味子多糖合用环磷酰胺抑瘤率达74.5%, 五味子多糖对荷瘤小鼠的免疫器官有较好的保护作用, 说明五味子多糖能抑制肿瘤的生长, 多糖的抑瘤作用可能不是直接杀死瘤细胞, 而与细胞凋亡及活化免疫细胞有关(黄玲等, 2003)。

4.1.5 抗HIV作用 五味子中活性成分联苯环辛二烯木脂素被证实在细胞和分子水平均具有抗艾滋病活性(李伟等, 2002)。Kadsulignan M体外对CEM-IW细胞系(T4淋巴细胞)有较强的抑制活性(Liu & Li, 1995b)。球蕊五味子中分到的三萜酸nigranoic acid 具有抑制HIV逆转录酶和多聚酶的作用(Sun et al., 1996)。凤庆南五味子茎的乙醇提取物体外对HIV病毒在H9淋巴细胞中的复制有显著抑制作用, 对从中分到的12个木脂素进行抗HIV生长试验, 7个化合物有活性, 其中gomisin G活性最强, 五味子酯丁, kadsuranin和五味子丙素也显示了强的抗HIV活性(Chen et al., 1996)。构效关系研究表明, 6位具苯甲酰基和7位取代羟基, 2,3位有亚甲氧基取代对增强抗HIV活性是很重要的(Chen et al., 1997)。从披针叶南五味子中分到的三萜类内酯lancilactone C在体外可抑制HIV病毒在H9淋巴细胞中的复制 (Chen et al., 1999)。从小花五味子中分离得到的木脂素Vladinol F具有显著的抗HIV活性, 李蓉涛等(2005a)从该植物中分离得到的新三萜Micrandilactone C能抑制HIV-1复制, 且对正常细胞具有极低的毒性, 有可能成为一类新的抗HIV药物。从狭叶五味子分离得到的三萜类化合物Lancifodilactone G和F均表现出了明显的抗HIV病毒活性(Xiao et al., 2005a, b)。从长梗南五味子藤茎中分离得到Longipedunin A和schisanlactone A对HIV-1蛋白酶具有较好的抑制作用(Sun et al., 2006)。

4.2 现代生理活性研究及主要物质基础

4.2.1 对免疫功能的影响 五味子水提物和五味子粗多糖具有升高白细胞及增强机体免疫、抗疲劳的作用(Ikeya et al., 1978a, b; Chen et al., 1997)。研究表明, 五味子提取物能促进唾液腺内半乳糖和乙酰胺半乳糖的合成, 促进免疫细胞分化, 增强免疫功能, 能明显对抗环磷酰胺所致小鼠脾脏和肠系膜淋巴结重量及细胞数目的减少, 并能增加免疫抑制小鼠的脾脏白髓总体积和淋巴结皮质总体积, 且对免疫器官的病理形态有一定的改善作用(黄秀兰等, 1997)。用五味子粗多糖给小鼠灌胃, 能明显提高小鼠的耐缺氧能力, 具有抗疲劳作用, 升高白细胞的同时, 可对抗环磷酰胺的免疫抑制作用, 使正常小鼠胸腺和脾脏的重量增加, 提高机体免疫力, 并增强小鼠静脉注射胶体碳粒的廓清速率, 减轻肌体损伤(李岩等, 1995; 于晓凤等, 1995)。

4.2.2 抗氧化 现代研究表明五味子的保肝作用与增强肝脏抗氧化能力有关(Ip et al., 1996)。研究表明, 很多木脂素都具有在体内外对多种氧化应激损伤的组织模型明显的保护作用。例如从五味子中提

取的五味子乙素、五味子二醇、五味子酮对维生素C/NADPH系统或$FeSO_4$/半胱氨酸系统诱发的脑、肝、肾微粒体脂质过氧化有明显抑制作用(黄治森等, 1990)。五味子乙素可对抗CCl_4引起的大鼠肝细胞膜脂质过氧化, 使肝细胞MDA的生成及LDH和GPT的释放均减少, 肝细胞的存活率提高, 这与它清除氧自由基有关(李莉, 刘耕陶, 1998; 张铁梅等, 1989; Ko & Lam, 2002; Ko et al., 2002)。从红花五味子中分离出的五味子酚(schisanhenol, SAL)能抑制大鼠肝、脑及心肌细胞MDA的生成, 可防止氧自由基引起的线粒体肿胀、破裂及ATP酶活性降低, 能保护脾淋巴细胞免受氧自由基的损伤, 提高淋巴细胞内GSH的含量, 拮抗过氧化氢对ConA刺激脾淋巴细胞增生及Fe^{2+}/Vit C对脾淋巴细胞膜的损伤(李莉, 1997)。电子自旋共振法和自旋捕捉技术证明, 五味子酚具有直接清除活性氧自由基的活性(林童俊等, 1990), 能降低脂质过氧化对脑神经细胞突触体膜的损伤程度, 从而起到保护作用, 且在体内外对多种氧化应激损伤脑组织模型都具有明显的保护作用(郭琼, 赵保路, 1995; 李莉, 刘耕陶, 1998)。从凤庆南五味子中分到的木脂素戈米辛J具有对抗羟自由基诱导的肝线粒体膜脂质过氧化和清除超氧化阴离子自由基的作用, 其作用比Vit E强, 剂量依赖性地抑制黄嘌呤/黄嘌呤氧化酶/鲁米诺化学发光(金昔陆等, 2000)。异形南五味子茎的乙醇提取物和其主要有效成分南五味子素可以明显减少CCl_4引起的小鼠肝脏过氧化脂质产物如MDA等的产生, 同时还可明显恢复SOD活性, 诱导肝脏抗氧化酶清除氧自由基(Kim et al., 1992)。由异形南五味子植物根部分离的联苯环辛烯类木脂素(heteroclitin A-G)具有明显的抗脂质过氧化作用, 其中异形南五味子丁素(heteroclitin D)对Fe^{2+}/Vit C诱导的肝匀浆脂质过氧化的抑制作用最强(李庆耀等, 1999a)。长梗南五味子木脂素在体外可抑制脂质过氧化反应及超氧阴离子的产生(Lu & Liu, 1992)。从五味子中分离得到的联苯环辛二烯木脂素deoxyschisandrin, gomisin N, and wuweizisu C能明显减弱谷氨酸诱导的神经细胞氧化性损伤作用, 其作用与升高谷胱苷肽水平, 提高谷胱苷肽过氧化物酶活性, 以及抑制细胞内过氧化物生成有关(Kim et al., 2004)。

4.2.3 PAF拮抗活性 研究发现, 多种木脂素有PAF拮抗活性, 五味子中的15个木脂素有不用程度的钙拮抗作用, 从五味子中提取戈米辛A、B、D、G、H五味子素、五味子丙素、前戈米辛等木脂素成分, 对PGF22引起的离体狗肠系膜动脉收缩有缓解作用, 而对$CaCl_2$引起的收缩具有抑制作用(郭冷秋等, 2006), 戈米辛J和异形南五味子丁素能阻滞血管平滑肌细胞膜的PM而发挥扩血管作用(李庆耀等, 1999b)。从凤庆南五味子和异形南五味子中分离得到的异形南五味子丁素heteroclitin D具有显著的钙拮抗、抗凝血和抑制血小板聚集等作用, 这些结果初步向我们提示了在民间南五味子属药用植物藤茎具有较强活血化瘀药理作用的活性物质基础。

5 五味子科药用植物亲缘学初探

我们通过对五味子科药用植物传统疗效、现代药理活性以及化学成分的整理和总结发现, 五味子科药用植物的现代药理活性研究与传统疗效之间有很好的相关性, 且很多活性也找到了相对应的物质基础, 同时也向我们提示两属植物功效主治上差别的物质基础与特征性成分有关。

北五味子中五味子醇甲和醇乙的含量都很高, 尤其是醇甲, 药典规定北五味子醇甲的含量不能少于0.4%, 而现代药理活性研究证明了五味子提取物及主要活性成分醇甲的镇静催眠抗惊厥作用, 这为五味子宁心安神的传统疗效提供了科学合理的解释。而五味子传统疗效中的滋补强壮、益肾固精在现代药理中可以找到如下关联: 第一、五味子粗多糖具有升高白细胞及增强机体免疫、抗疲劳的作用; 第二、五味子的保肝作用, 发挥五味子保肝作用的成分联苯环辛烯类木脂素通常在八元环的C-6和C-9没有酯化取代集基团; 第三、联苯环辛烯类木脂素的抗氧化作用, 据医学研究表明一些老年性疾病如帕金森病, 老年性痴呆, 糖尿病等病的发生与体内自由基反应密切相关, 自由基可引发脂质过氧化造成细胞损伤, DNA断裂, 蛋白交联等, 而五味子属植物中很多联苯环辛烯类木脂素在体内外对多种氧化应激损伤的组织模型都具有明显的保护作用, 同样, 这类木脂素往往在八元环的C-6和C-9没有酯化取代基团, 很多研究也表明一些木脂素正是通过抗脂质过氧化来发挥保肝作用的。这类成分在五味子的果实以及南北五味子的藤茎中广泛分布, 今后有望从这些较为原始的联苯环辛烯类木脂素中深入研

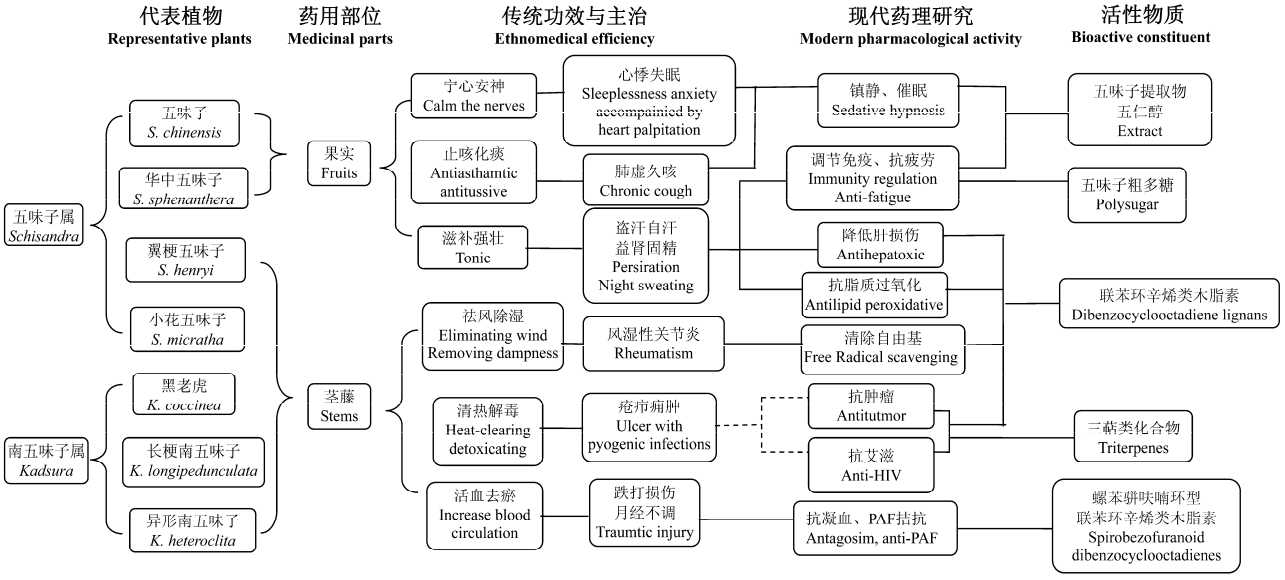


图13 五味子药用植物传统疗效-现代药理作用-活性成分之间可能存在的联系

Fig. 13. Proposed relationships between ethnopharmacology, pharmacology and bioacitive constituents from family Schisandraceae.

究开发, 挖掘出增强机体免疫力, 延缓衰老的抗氧化药物(图13)。

螺苯骈呋喃骨架的联苯环辛烯类木脂素是一类特别值得注意的化学成分, 这是一类较联苯环辛烯类木脂素更为进化的成分, 到目前为止, 这类成分绝大多数只在南五味子属植物的藤茎中分布, 可以被认为是南五味子属植物中的特征性活性成分, 如南五木脂素C–K、异形南五味子素D–G和凤庆南五味子素A–D等, 这类化合物的特点是具有钙拮抗、抗凝血和抑制血小板聚集作用, 这不仅初步说明了民间南五味子属药用植物藤茎具有较强活血化瘀药理作用的活性物质基础, 也向我们提示在对南五味子属的药材质量标准研究中, 可以考虑以此类成分作为定性定量指标。同时也有研究报道, 这一类木脂素中尤其是在C-9位上有酯化取代基团的, 往往也具有抗脂质过氧化的作用。

《本草纲目》曾有对五味子的记载: “对痰咳并喘, 百药不效者均可治愈”。随着研究的不断深入, 五味子科药用植物中越来越多的结构新颖的木脂素和三萜类成分被发现, 因此这些成分的一些特殊的药理活性也得到了越来越广泛的关注。在最近的研究中我们发现, 五味子除了传统的保肝作用以外, 很多三萜和木脂素具有相当好的抗肿瘤和抗HIV活性, 这或许就是传统意义上的“百药不效者均可治愈”。通过总结, 我们发现一些联苯环辛烯类的木脂素尤其是在八元环C-6、C-9位上具有羟基或者酯化取代比如当归酰基取代的比八元环无取代的木脂素具有更好的抗HIV和抗肿瘤活性, 这向我们提示, 发挥传统保肝作用的木脂素更为原始, 而衍化程度相对进化的木脂素则更具有抗肿瘤和抗HIV的潜力。对于环菠萝蜜烷三萜来说, 在取代基相同的情况下, A环裂环将增强抗肿瘤和抗HIV活性, 这一类化合物就传统的环菠萝蜜烷类更为进化, 是值得深入研究和开发的化合物, 它们在五味子科和八角科的药用植物中均有分布, 南五味子属的异形南五味子、长梗南五味子、黑老虎这几种药用植物在民间应用较多、分布较广, 它们的藤茎中都曾报道有A环裂环的环菠萝蜜烷型三萜类化合物, 在五味子属的铁箍散、翼梗五味子的藤茎中也有此类化合物的报道。最新的研究报道显示更为进化的7/7/5/6型三萜内酯体外对肿瘤细胞株显示了很强的细胞毒活性, 目前主要在南五味子属的长梗南五味子中发现此类化合物, 有望通过对此类成分的深入挖掘而从中开发抗肿瘤预防用药, 同样, 从狭叶五味子和小花五味子等分离得到的成环复杂、氧化程度很高的类三萜内酯也在抗肿瘤和抗HIV中显示了很好的潜力, 这向我们提示, 进化程度更高的三萜化合物很值得关注。

通过上述比较和总结, 我们不难发现在五味子科植物中发挥传统疗效的往往是那些较为原始的化合物, 而新颖的活性往往都在进化程度较高的化合物中发现。我国五味子科植物资源十分丰富, 大量系统、深入、客观全面的研究仍有待继续, 以使该科的药用植物亲缘学研究得到完善。

另外, 药典已将五味子属华中五味子*S. sphaerandra*的干燥果实定为南五味子, 而传统将*Kadsura*译为南五味子属, *K. japonica* (L.) Dunal和*K. longipedunculata* Finet & Gagnep.的中文名称也多被用为南五味子, 药典中的南五味子与*Kadsura*并非从属关系, 如此译名容易造成名称混乱和概念混淆, 作者建议今后应将*Kadsura*译为更恰当的属名。

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