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## 大瑶山甜茶正丁醇部位化学成分研究\*

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**摘要目的:**研究大瑶山甜茶正丁醇部位中的二萜类化学成分,为探索其活性物质奠定基础。**方法:**采用95%乙醇提取药材,提取液回收至无醇味后溶于水,依次用石油醚、乙酸乙酯和正丁醇萃取,减压干燥后获得相应萃取物,综合运用各种色谱技术对正丁醇萃取物进行分离纯化,获取二萜类化合物,通过NMR对得到的化合物进行结构鉴定。**结果:**从大瑶山甜茶中分离得到10个二萜类化合物,分别鉴定为7β, 17-dihydroxy-16β-ent-kauran-19-oic acid 19-O-β-D-glucopyranoside ester (1), 7β, 17-dihydroxy-ent-kaur-15-en-19-oic acid 19-O-β-D-glucopyranoside ester (2), 13-[(O-β-D-glucopyranosyl)oxy]ent-kaur-16-en-19-oic acid 2-O-β-D-glucopyranosyl-β-D-glucopyranosyl ester (3), 12-α-[(2-O-β-D-glucopyranosyl-β-D-glucopyranosyl)oxy]ent-kaur-16-en-19-oic acid β-D-glucopyranosyl ester (4), glaucocalyxin G (5), β-D-glucopyranosyl 17-hydroxy-ent-kauran-19-oate-16-O-β-D-glucopyranoside (6), cussoracosides E (7), 17-O-β-D-glucopyranosyl-16α-ent-kauran-19-oic acid (8), cussovantoxide A (9), cussovantoxide C (10)。**结论:**化合物1-10首次从大瑶山甜茶中分离得到。

**关键词:**大瑶山甜茶;正丁醇部位;化学成分**中图分类号:**S571.1; R284.2 **文献标识码:**A **文章编号:**1673-6273(2019)03-434-05

## Chemical Studies on the *n*-Butanol Extract of *Rubus suavissimus* S. Lee\*

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**ABSTRACT Objective:** To study the diterpenoids of *n*-butanol extract of *Rubus suavissimus* S. Lee., and to establish the foundation for its active substances. **Methods:** The medicinal materials were extracted by 95% EtOH. The extract was recovered to non-alcoholic taste and dissolved in water. The extract was successively extracted with petroleum ether, ethyl acetate and *n*-butanol. After drying under reduced pressure, the corresponding extract was obtained, and the *n*-butanol extract was separated and purified by various chromatographic techniques. **Results:** The structures of the compounds were established as 7β, 17-dihydroxy-16β-ent-kauran-19-oic acid 19-O-β-D-glucopyranoside ester (1), 7β, 17-dihydroxy-ent-kaur-15-en-19-oic acid 19-O-β-D-glucopyranoside ester (2), 13-[(O-β-D-glucopyranosyl)oxy]ent-kaur-16-en-19-oic acid 2-O-β-D-glucopyranosyl-β-D-glucopyranosyl ester (3), 12-α-[(2-O-β-D-glucopyranosyl-β-D-glucopyranosyl)oxy]ent-kaur-16-en-19-oic acid β-D-glucopyranosyl ester (4), glaucocalyxin G (5), β-D-glucopyranosyl 17-hydroxy-ent-kauran-19-oate-16-O-β-D-glucopyranoside (6), cussoracosides E (7), 17-O-β-D-glucopyranosyl-16α-ent-kauran-19-oic acid (8), cussovantoxide A (9), and cussovantoxide C (10). **Conclusion:** Compounds 1-10 were obtained from *Rubus suavissimus* S. Lee firstly.

**Key words:** *Rubus suavissimus* S. Lee; *n*-Butanol extracts; Chemical compounds**Chinese Library Classification(CLC):** S571.1; R284.2 **Document code:** A**Article ID:** 1673-6273(2019)03-434-05

### 前言

大瑶山甜茶(*Rubus suavissimus* S. Lee)是蔷薇科悬钩子属植物,别名为甘叶悬钩子,是多年生有刺灌木,主产于我国广西壮族自治区大瑶山地区。大瑶山甜茶性凉,味甘、平,有清热、润肺、消肿止痛、祛痰和止咳等功效<sup>[1]</sup>。大瑶山甜茶除具备普通绿茶的功效外同时还具有抗氧化、抗过敏、减肥、防治心血管疾病、预防中风、防癌作用、预防牙齿疾病等药效,与罗汉果、合浦

珍珠、广西香料等齐名为广西四大名品<sup>[2]</sup>。大瑶山甜茶的甜度很高,每公斤干茶叶的甜度相当于15公斤蔗糖的甜度,其具有甜味的主要成分为甜茶素,每公斤甜茶素相当于300公斤的蔗糖甜度。同时甜茶素是一种二萜葡萄糖低热量甜料,是能替代糖的高甜度、低热能、无毒的天然产物。目前只局限于对大瑶山甜茶的主要化学成分(甜茶素)研究,但对甜茶素外其他衍生物研究很少<sup>[3]</sup>。本文拟研究大瑶山甜茶正丁醇部位二萜类化学成分,为开发大瑶山甜茶奠定物质基础。

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## 1 材料与方 法

### 1.1 仪器与材料

1.1.1 仪器 Brucker-500 和 Brucker-800 核磁共振仪 (布鲁克公司, 美国); 高效液相色谱仪 (岛津公司, 日本); YMC C18 制备型色谱柱 (250 × 20 mm, 5 μm, YMC 公司, 日本); 聚酰胺树脂 (60~90 目, 浙江台州市路桥四甲生化塑料厂, 中国)。

1.1.2 材料 实验材料于 2016 年 8 月采集于广西金秀大瑶山, 经黑龙江中医药大学陈效忠副教授鉴定为大瑶山甜茶 (*Rubus suavisissimus* S. Lee) 的叶, 标本储存于黑龙江中医药大学佳木斯学院标本馆 (hzyj-201608002)。

### 1.2 提取与分离

95%乙醇提取大瑶山甜茶 (3.0 kg) 3 次, 10 L 溶剂 / 次, 每次 1 h, 得到浸膏 (300 g)。浸膏分散于水中, 分别用石油醚、乙酸乙酯和正丁醇萃取, 得到相应的 4 个萃取部位。正丁醇萃取物 (100.0 g) 过聚酰胺树脂柱色谱, 分别用不同浓度乙醇洗脱, 其中 30%乙醇洗脱物 (30.0 × g) 过 ODS 柱色谱得到 25 个流分 S1-S25。制备型 HPLC (乙腈 - 水, 30:70, 流速 5.0 mL/min, 检测波长为 210 nm) 对 S3 进行分离, 得到化合物 3 (10.0 mg, Rt = 10.5 min) 和 4 (9.0 mg, Rt = 15.0 min)。制备型 HPLC (乙腈 - 水, 40:60, 流速 5.0 mL/min) 对 S7 进行分离, 得到化合物 6 (8.0 mg, Rt = 18.0 min) 和 10 (10.0 mg, Rt = 20.0 min)。制备型 HPLC (乙腈 - 水, 50:50, 流速 5.0 mL/min) 对 S12 进行分离, 得到化合物 1 (10.0 mg, Rt = 23.5 min), 2 (9.0 mg, Rt = 25.8 min) 和 5 (3.0 mg, Rt = 27.0 min)。制备型 HPLC (乙腈 - 水, 55:45, 流速 5.0 mL/min) 对 S18 进行分离, 得到化合物 7 (7.0 mg, Rt = 31.0 min), 8 (3.0 mg, Rt = 33.5 min) 和 9 (11.0 mg, Rt = 35.2 min)。

## 2 结果

化合物 1 白色粉末。<sup>1</sup>H NMR (CDCl<sub>3</sub>, 500 MHz) δ: 1.88 (1H, m, H-1a), 0.94 (1H, m, H-1b), 1.94 (1H, m, H-2a), 1.45 (1H, m, H-2b), 2.22 (1H, m, H-3a), 1.13 (1H, m, H-3b), 1.78 (1H, d, J = 13.0 Hz, H-5), 2.18 (1H, dd, J = 13.0 Hz, J = 14.5 Hz, H-6a), 1.97 (1H, m, H-6b), 3.5 (1H, brs, H-7), 1.43 (1H, m, H-9), 1.63 (1H, m, H-11a), 1.57 (1H, m, H-11b), 1.63 (1H, m, H-12a), 1.43 (1H, m, H-12b), 2.11 (1H, m, H-13), 1.80 (1H, d, J = 11.5 Hz, H-14a), 1.08 (1H, m, H-14b), 1.71 (1H, dd, J = 3.5 Hz, J = 10.0 Hz, H-15a), 1.12 (1H, m, H-15b), 1.94 (1H, m, H-16), 3.35 (1H, m, H-17), 1.22 (2H, s, H-18), 0.99 (3H, s, H-20), 5.42 (1H, d, J = 8.0 Hz, H-1'), 3.38 (1H, m, H-2'), 3.45 (1H, m, H-3'), 3.39 (1H, m, H-4'), 3.39 (1H, m, H-5'), 3.86 (1H, d, J = 11.5 Hz, H-6a'), 3.71 (1H, dd, J = 4.0 Hz, J = 11.5 Hz, H-6b'); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 125 MHz) δ: 41.8 (C-1), 20.2 (C-2), 39.1 (C-3), 44.7 (C-4), 49.5 (C-5), 30.7 (C-6), 78.7 (C-7), 49.8 (C-8), 50.6 (C-9), 40.5 (C-10), 19.5 (C-11), 33.0 (C-12), 39.5 (C-13), 37.2 (C-14), 42.6 (C-15), 44.7 (C-16), 67.7 (C-17), 28.8 (C-18), 178.7 (C-19), 16.3 (C-20), 95.7 (C-1'), 74.1 (C-2'), 78.7 (C-3'), 71.1 (C-4'), 78.6 (C-5'), 62.4 (C-6')。以上数据与文献基本一致<sup>[4]</sup>, 故鉴定化合物为 7β,17-dihydroxy-16β-ent-kauran-19-oic acid 19-O-β-D-glucopyranoside ester (见图 1)。

化合物 2 白色粉末。<sup>1</sup>H NMR (CDCl<sub>3</sub>, 500 MHz) δ: 1.87 (1H, d, J = 13.5 Hz, H-1a), 1.03 (1H, dd, J = 3.5 Hz, J = 13.5 Hz, H-1b), 1.96 (1H, m, H-2a), 1.44 (1H, dt, J = 5.0 Hz, J = 10.0 Hz, H-2b), 2.22 (1H, m, H-3a), 1.12 (1H, dd, J = 4.0 Hz, J = 13.5 Hz, H-3b), 1.78 (1H, m, H-5), 2.23 (1H, m, H-6a), 1.96 (1H, m, H-6b), 3.59 (1H, brs, H-7), 1.39 (1H, d, J = 7.5 Hz, H-9), 1.64 (1H, m, H-11a), 1.58 (1H, m, H-11b), 1.52 (1H, m, H-12), 2.57 (1H, m,

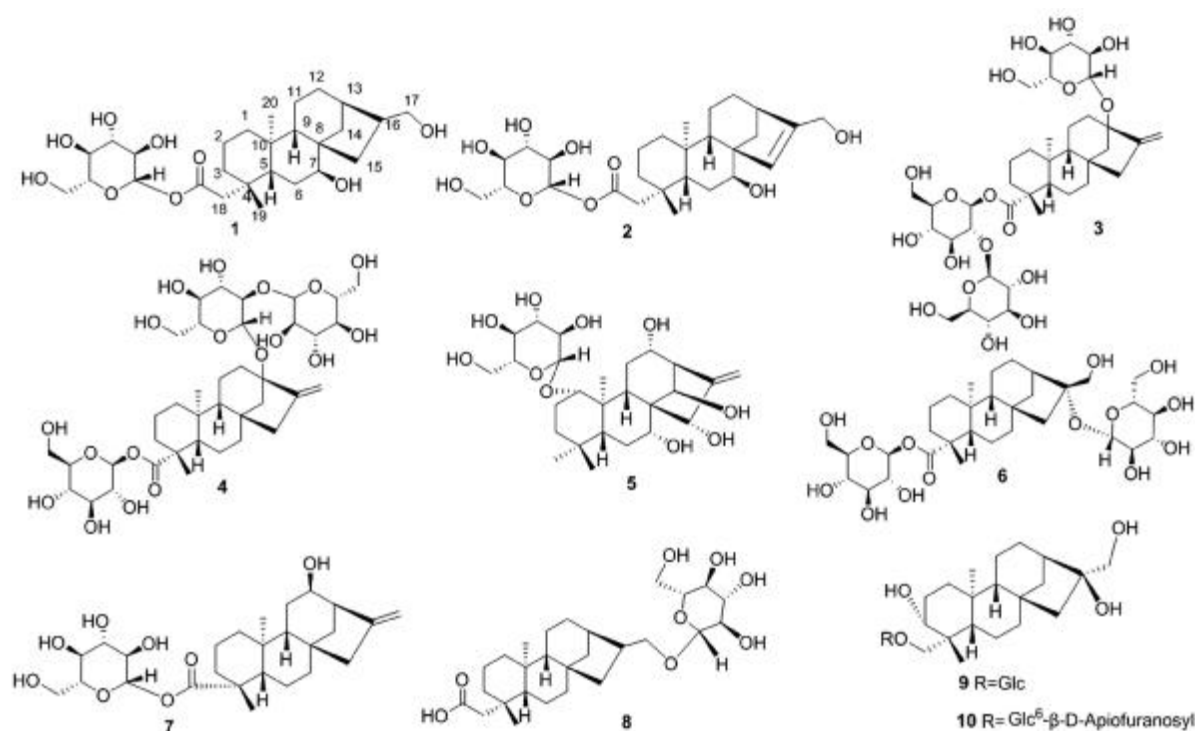


图 1 化合物 1-10 的结构

Fig.1 The structures of compounds 1-10

H-13), 2.06(1H, d,  $J = 10.5$  Hz, H-14a), 1.42(1H, dd,  $J = 7.5$  Hz,  $J = 10.5$  Hz, H-14b), 5.81 (1H, s, H-15), 4.13 (1H, d,  $J = 1.0$  Hz, H-17), 1.22(2H, s, H-18), 1.02(3H, s, H-20), 5.42(1H, d,  $J = 7.5$  Hz, H-1'), 3.38 (1H, m, H-2'), 3.42 (1H, m, H-3'), 3.40 (1H, m, H-4'), 3.39 (1H, m, H-5'), 3.85 (1H, dd,  $J = 2.0$  Hz,  $J = 12.0$  Hz, H-6a'), 3.71 (1H, dd,  $J = 4.0$  Hz,  $J = 12.0$  Hz, H-6b');  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 125 MHz)  $\delta$ : 41.7 (C-1), 20.2 (C-2), 39.1 (C-3), 44.7 (C-4), 48.3 (C-5), 29.3 (C-6), 75.6 (C-7), 54.3 (C-8), 43.6 (C-9), 40.9 (C-10), 19.7 (C-11), 26.3 (C-12), 42.2 (C-13), 43.5 (C-14), 132.1 (C-15), 148.1 (C-16), 61.2 (C-17), 28.8 (C-18), 178.6 (C-19), 16.1 (C-20), 96.6 (C-1'), 74.1 (C-2'), 78.7 (C-3'), 71.1 (C-4'), 78.7 (C-5'), 62.4 (C-6')。以上数据与文献<sup>[4]</sup>基本一致,故鉴定化合物为  $\beta$ , 17-dihydroxy-ent-kaur-15-en-19-oic acid 19-O- $\beta$ -D-glucopyranoside ester(见图1)。

化合物3白色粉末。 $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 800 MHz)  $\delta$ : 1.75 (1H, m, H-1a), 0.76(1H, m, H-1b), 2.17(1H, m, H-2a), 1.70(1H, m, H-2b), 2.14(1H, m, H-3a), 1.82(1H, m, H-3b), 0.99(1H, m, H-5), 2.20(1H, m, H-6a), 1.91(1H, m, H-6b), 1.51(1H, m, H-7a), 1.31(1H, m, H-7b), 0.93(1H, m, H-9), 1.48(1H, m, H-11), 2.75 (1H, m, H-12a), 1.10(1H, m, H-12b), 2.45(1H, m, H-14a), 1.94 (1H, m, H-14b), 2.10 (1H, m, H-15), 5.64 (1H, s, H-17a), 5.10 (1H, m, H-17b), 1.42(2H, s, H-18), 0.99(3H, s, H-20), 6.23(1H,  $J = 6.0$  Hz, glc'-1), 5.10(1H,  $J = 6.5$  Hz, glc'2-1), 5.12(1H,  $J = 6.3$  Hz, glc-1);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 200 MHz)  $\delta$ : 40.8 (C-1), 20.2 (C-2), 38.9 (C-3), 44.5 (C-4), 57.6 (C-5), 22.2 (C-6), 41.9 (C-7), 42.2 (C-8), 54.2 (C-9), 39.8 (C-10), 20.7 (C-11), 38.0 (C-12), 87.2 (C-13), 44.8 (C-14), 48.6 (C-15), 153.8 (C-16), 105.5 (C-17), 29.4 (C-18), 176.1 (C-19), 16.5 (C-20), 93.8 (glc'-1), 105.8 (glc'2-1), 99.7(glc-1)。以上数据与文献基本一致<sup>[9]</sup>,故鉴定化合物为 13-[O- $\beta$ -D-glucopyranosyl]oxy]ent-kaur-16-en-19-oic acid 2-O- $\beta$ -D-glucopyranosyl- $\beta$ -D-glucopyranosyl ester(见图1)。

化合物4白色粉末。 $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 500 MHz)  $\delta$ : 0.79 (1H, m, H-1), 2.13(1H, m, H-2a), 1.38(1H, m, H-2b), 2.36(1H, m, H-3), 1.03 (1H, m, H-5), 2.41 (1H, m, H-6a), 1.84 (1H, m, H-6b), 2.78(1H, m, H-7), 1.01(1H, m, H-9), 1.59(1H, m, H-11), 4.11(1H, brs, H-12), 2.94(1H, brs, H-13), 1.42(1H, m, H-14a), 1.05(1H, m, H-14b), 2.23(1H, m, H-15a), 1.91(1H, m, H-15b), 5.24(1H, s, H-17a), 4.90(1H, s, H-17b), 1.26(2H, s, H-18), 1.04 (3H, s, H-20), 6.18(1H, d,  $J = 8.0$  Hz, glc'-1), 5.01(1H, d,  $J = 7.6$  Hz, glc-1), 5.24 (1H, m, glc2-1);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 125 MHz) $\delta$ : 40.2 (C-1), 19.7 (C-2), 39.1 (C-3), 44.6 (C-4), 57.9 (C-5), 21.1 (C-6), 39.6 (C-7), 34.9 (C-8), 51.7 (C-9), 44.6 (C-10), 27.3 (C-11), 78.4 (C-12), 42.0 (C-13), 39.9 (C-14), 49.0 (C-15), 148.4 (C-16), 109.5 (C-17), 29.1 (C-18), 177.4 (C-19), 13.3 (C-20), 96.4(glc'-1), 103.0(glc-1), 106.4(glc2-1)。以上数据与文献<sup>[5]</sup>基本一致,故鉴定化合物为 12- $\alpha$ -[(2-O- $\beta$ -D-glucopyranosyl- $\beta$ -Dglucopyranosyl)oxy]ent-kaur-16-en-19-oic acid  $\beta$ -D-glucopyranosyl ester(见图1)。

化合物5白色粉末。 $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 500 MHz)  $\delta$ : 3.19 (1H, dd,  $J = 10.0, 4.0$  Hz, H-1), 1.60(1H, m, H-2a), 1.75(1H, m, H-2b),

1.18(1H, m, H-3a), 1.32(1H, m, H-3b), 0.76(1H, m, H-5), 1.65 (1H, m, H-6a), 1.93(1H, m, H-6b), 3.58(1H, m, H-7), 1.76(1H, s, H-9), 1.63 (1H, m, H-11a), 2.47 (1H, m, H-11b), 4.88 (1H, s, H-12), 2.41(1H, d,  $J = 4.0$  Hz, H-13), 4.65(1H, s, H-14), 3.56(1H, s, H-15), 4.90 (1H, s, H-17a), 5.08 (1H, s, H-17b), 0.86 (2H, s, H-18), 0.83(3H, s, H-19), 1.29(3H, s, H-20), 4.57(1H, d,  $J = 8.0$  Hz, H-1'), 3.50 (1H, m, H-2'), 3.60 (1H, m, H-3'), 3.46 (1H, m, H-4'), 3.46(1H, m, H-5'), 3.86(1H, m, H-6'a), 3.70(1H, m, H-6'b);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 125 MHz) $\delta$ : 90.0 (C-1), 29.7 (C-2), 38.9 (C-3), 32.8 (C-4), 51.6 (C-5), 26.7 (C-6), 73.6 (C-7), 53.6 (C-8), 49.5 (C-9), 43.3 (C-10), 26.3 (C-11), 71.9 (C-12), 56.8 (C-13), 74.5 (C-14), 72.6 (C-15), 156.2 (C-16), 106.5 (C-17), 32.6 (C-18), 21.8 (C-19), 14.0 (C-20), 103.5 (C-1'), 74.6 (C-2'), 76.9 (C-3'), 70.3 (C-4'), 76.9 (C-5'), 61.5 (C-6')。以上数据与文献基本一致<sup>[6]</sup>,故鉴定化合物为 glaucocalyxin G(见图1)。

化合物6白色粉末。 $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 500 MHz)  $\delta$ : 1.70(1H, m, H-1a), 1.11(1H, m, H-1b), 1.30(1H, m, H-2a), 2.22(1H, m, H-2b), 2.30(1H, m, H-3a), 0.93(1H, m, H-3b), 1.05(1H, m, H-5), 2.33(1H, m, H-6a), 1.88(1H, m, H-6b), 1.60(1H, m, H-7a), 1.30 (1H, m, H-7b), 0.95(1H, m, H-9), 1.66(1H, m, H-11a), 1.50(1H, m, H-11b), 1.55 (1H, m, H-12a), 1.38 (1H, m, H-12b), 2.65(1H, m, H-13), 2.10(1H, m, H-14a), 1.60(1H, m, H-14b), 1.68(1H, m, H-15a), 1.95(1H, m, H-15b), 3.78(1H, d,  $J = 10$  Hz, H-17a), 3.82 (1H, d,  $J = 10$  Hz, H-17b), 1.28(3H, s, H-20), 5.00(1H, d,  $J = 8.0$  Hz, H-1'), 6.20 (1H, d,  $J = 8.0$  Hz, H-1'');  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 125 MHz) $\delta$ : 41.1 (C-1), 19.0 (C-2), 38.6 (C-3), 44.5 (C-4), 57.5 (C-5), 22.2 (C-6), 42.3 (C-7), 44.1 (C-8), 56.2 (C-9), 40.3 (C-10), 18.9 (C-11), 26.5 (C-12), 40.1 (C-13), 37.9 (C-14), 48.6 (C-15), 87.3 (C-16), 66.8 (C-17), 28.8 (C-18), 177.1 (C-19), 15.9 (C-20), 99.9 (C-1'), 75.5 (C-2'), 78.3 (C-3'), 71.8 (C-4'), 78.8 (C-5'), 63.3 (C-6'), 95.7 (C-1''), 75.1 (C-2''), 79.6 (C-3''), 71.3 (C-4''), 79.3 (C-5''), 62.3 (C-6')。以上数据与文献基本一致<sup>[7]</sup>,故鉴定化合物为  $\beta$ -D-glucopyranosyl 17-hydroxy-ent-kauran-19-oate-16-O- $\beta$ -D-glucopyranoside(见图1)。

化合物7白色粉末。 $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 500 MHz)  $\delta$ : 0.73 (1H, m, H-1a), 1.65(1H, m, H-1b), 1.36(1H, m, H-2a), 2.06(1H, m, H-2b), 2.36(1H, br d,  $J = 14.0$  Hz, H-3a), 1.03(1H, m, H-3b), 1.07(1H, br d,  $J = 0.0$  Hz, H-5), 2.20(1H, m, H-6a), 1.98(1H, m, H-6b), 1.38(1H, m, H-7a), 1.52(1H, m, H-7b), 1.02(1H, m, H-9), 2.03 (1H, m, H-11a), 1.73 (1H, m, H-11b), 4.13 (1H, m, H-12), 2.79(1H, br s, H-13), 0.98(1H, m, H-14a), 2.08(1H, m, H-14b), 2.06 (1H, br s, H-15a), 2.07 (1H, br s, H-15b), 5.23 (1H, br s, H-17a), 5.02 (1H, br s, H-17b), 1.28 (2H, s, H-18), 1.26 (3H, s, H-20), 6.19(1H, d,  $J = 8.3$  Hz, H-1'), 5.20(1H, d,  $J = 2.0$  Hz, H-1'');  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 125 MHz) $\delta$ : 38.9 (C-1), 28.9 (C-2), 78.3 (C-3), 49.9 (C-4), 56.6 (C-5), 21.9 (C-6), 40.6 (C-7), 43.8 (C-8), 56.9 (C-9), 39.3 (C-10), 29.5 (C-11), 71.3 (C-12), 51.9 (C-13), 39.7 (C-14), 49.3 (C-15), 150.9 (C-16), 106.46 (C-17), 24.6 (C-18), 176.7 (C-19), 16.3 (C-20), 96.1 (C-1'), 74.3 (C-2'), 79.7 (C-3'),



70.9 (C-4<sup>''</sup>), 79.2 (C-5<sup>''</sup>), 61.9 (C-6<sup>''</sup>)。以上数据与文献基本一致<sup>[8]</sup>,故鉴定化合物为 *cussoacosides E* (见图 1)。

化合物 8 白色粉末。<sup>1</sup>H NMR (CDCl<sub>3</sub>, 500 MHz) δ: 1.81 (1H, m, H-1a), 0.82 (1H, dt, *J* = 12.0, 3.0 Hz, H-1b), 1.81 (1H, m, H-2a), 1.33 (1H, m, H-2b), 2.03 (1H, m, H-3a), 0.95 (1H, m, H-3b), 0.98 (1H, m, H-5), 1.73 (1H, m, H-6a), 1.72 (1H, m, H-6b), 1.42 (1H, m, H-7), 0.96 (1H, m, H-9), 1.55 (1H, m, H-11), 1.40 (1H, m, H-12a), 1.37 (1H, m, H-12b), 2.08 (1H, m, H-13), 1.76 (1H, m, H-14a), 1.02 (1H, m, H-14b), 1.50 (1H, m, H-15a), 0.85 (1H, m, H-15b), 1.98 (1H, m, H-16), 3.56 (1H, m, H-17a), 3.18 (1H, m, H-17b), 1.13 (2H, s, H-18), 12.3 (1H, brs, H-19-COOH), 0.88 (3H, s, H-20), 4.09 (1H, d, *J* = 8.0 Hz, H-1'), 2.93 (1H, m, H-2'), 3.13 (1H, m, H-3'), 3.05 (1H, m, H-4'), 3.07 (1H, m, H-5'), 3.68 (1H, d, *J* = 11.0 Hz, H-6'a), 3.45 (1H, d, *J* = 12.0 Hz, H-6'b); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 40.4 (C-1), 18.9 (C-2), 37.7 (C-3), 42.9 (C-4), 56.3 (C-5), 22.5 (C-6), 41.3 (C-7), 44.6 (C-8), 54.9 (C-9), 40.3 (C-10), 18.6 (C-11), 31.0 (C-12), 37.7 (C-13), 36.9 (C-14), 45.3 (C-15), 40.2 (C-16), 73.5 (C-17), 28.9 (C-18), 178.7 (C-19), 15.6 (C-20), 103.2 (C-1'), 73.6 (C-2'), 76.9 (C-3'), 70.3 (C-4'), 76.9 (C-5'), 61.3 (C-6')。以上数据与文献基本一致<sup>[9]</sup>,故鉴定化合物为 17-O-β-D-glucopyranosyl-16α-ent-kauran-19-oic acid (见图 1)。

化合物 9 白色粉末。<sup>1</sup>H NMR (CDCl<sub>3</sub>, 500 MHz) δ: 0.93 (1H, m, H-1a), 1.87 (1H, m, H-1b), 1.96 (1H, m, H-2a), 2.57 (1H, m, H-2b), 3.37 (1H, m, H-3a), 1.06 (1H, dd, *J* = 12.8, 3.0 Hz, H-5), 2.03 (1H, m, H-6a), 2.38 (1H, m, H-6b), 1.47 (2H, m, H-7a 和 H-7b), 1.75 (1H, m, H-7b), 0.98 (1H, dd, *J* = 7.3, 3.9 Hz, H-9), 1.51 (1H, m, H-11), 1.45 (1H, m, H-12a), 1.88 (1H, m, H-12b), 2.36 (1H, brs, H-13), 2.01 (1H, m, H-14a), 2.13 (1H, m, H-14b), 1.657 (1H, m, H-15a), 1.83 (1H, m, H-15b), 4.06 (1H, m, H-17a), 4.14 (1H, m, H-17b), 1.66 (2H, s, H-18), 1.29 (3H, s, H-20), 6.19 (1H, d, *J* = 7.8 Hz, H-1'); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 125 MHz) δ: 39.9 (C-1), 29.1 (C-2), 78.5 (C-3), 50.0 (C-4), 56.7 (C-5), 22.1 (C-6), 42.5 (C-7), 43.7 (C-8), 57.2 (C-9), 39.8 (C-10), 19.7 (C-11), 27.5 (C-12), 41.7 (C-13), 38.3 (C-14), 53.3 (C-15), 79.8 (C-16), 70.8 (C-17), 24.5 (C-18), 176.7 (C-19), 15.8 (C-20), 96.1 (C-1'), 74.3 (C-2'), 79.9 (C-3'), 71.0 (C-4'), 79.3 (C-5'), 61.9 (C-6')。以上数据与文献基本一致<sup>[10]</sup>,故鉴定化合物为 *cussovantose A* (见图 1)。

化合物 10 白色粉末。<sup>1</sup>H NMR (CDCl<sub>3</sub>, 500 MHz) δ: 0.73 (1H, m, H-1a), 1.68 (1H, m, H-1b), 1.28 (1H, m, H-2a), 1.69 (1H, m, H-2b), 0.88 (1H, m, H-3a), 2.03 (1H, m, H-3b), 1.05 (1H, m, H-5), 1.29 (1H, m, H-6a), 1.57 (1H, m, H-6b), 1.29 (1H, m, H-7ab), 0.67 (1H, m, H-9), 1.56 (2H, m, H-11a 和 H-11b), 1.47 (1H, m, H-12a), 2.23 (1H, m, H-12b), 2.38 (1H, brs, H-13), 1.06 (1H, m, H-14a), 1.95 (1H, m, H-14b), 1.58 (1H, m, H-15a), 1.64 (1H, m, H-15b), 3.75 (1H, m, H-17a), 3.80 (1H, m, H-17b), 1.15 (2H, s, H-18), 3.51 (1H, m, H-19a 和 H-19b), 1.11 (3H, s, H-20), 4.68 (1H, d, *J* = 7.8 Hz, H-1'), 5.65 (1H, d, *J* = 2.3 Hz, H-1''); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 125 MHz) δ: 39.8 (C-1), 28.9 (C-2), 78.5 (C-3),

49.9 (C-4), 56.3 (C-5), 22.5 (C-6), 42.8 (C-7), 44.7 (C-8), 56.9 (C-9), 39.7 (C-10), 19.3 (C-11), 26.8 (C-12), 45.9 (C-13), 37.6 (C-14), 53.6 (C-15), 81.8 (C-16), 66.5 (C-17), 24.4 (C-18), 176.6 (C-19), 15.9 (C-20), 96.1 (C-1'), 74.2 (C-2'), 79.9 (C-3'), 70.9 (C-4'), 79.3 (C-5'), 62.0 (C-6')。以上数据与文献<sup>[10]</sup>基本一致,故鉴定化合物为 *cussovantose C* (见图 1)。

### 3 讨论

甜茶富含甜茶素、茶多酚、黄酮等多种活性成分,具有“茶、糖、药”3种用途。经中国人民解放军第 181 医院药理室实验证明:甜茶是一种低毒害、轻微副作用的物质,长期食用对肝、肾功能无影响、对生殖能力无影响且无蓄积中毒现象。因此,甜茶可以作为一种理想的健康饮料。大瑶山甜茶是广西金秀大瑶山当地居民日常生活中常见的饮品,口感甘甜。大瑶山甜茶中的黄酮类色素和甜味成分,可作为食品添加剂;其中的抗过敏有效成分,可开发为药物和化妆品的添加剂。此外,大瑶山甜茶营养丰富,富含的多种氨基酸和人体必需的微量元素使其成为一种珍贵的茶叶,作为滋补的珍品。大瑶山甜茶的提取物甜茶素通过刺激胰岛中胰岛素的分泌来降低血糖<sup>[11]</sup>,有效解决了糖尿病患者不能食用甜食的问题,为糖尿病患者带来了福音<sup>[12]</sup>。研究表明甜茶中多酚物质含量与其抗氧化活性两者存在显著相关性<sup>[13]</sup>,表明多酚物质成分是甜茶具有抗氧化活性的关键物质<sup>[14]</sup>。甜茶中多酚类化合物主要包括花黄素类、黄酮醇类、酚酸类、花色素类等<sup>[15]</sup>,可抑制产生动脉粥样硬化、调节血脂、预防内出血和冠心病,起到增强毛细血管舒张的作用<sup>[16]</sup>。吴燕春等研究表明广西甜茶中的总黄酮类化合物具有体外抗肿瘤的生物活性<sup>[17]</sup>。结果表明总黄酮体外可抑制小鼠肝癌 H22 细胞、肉瘤 S180 细胞和淋巴白血病 L1210 细胞的增殖。变形链球菌是目前医学界公认的最主要口腔致龋病菌<sup>[18]</sup>,有研究报道称,甜茶素对其黏附能力、产酸能力、葡萄糖基转移酶活力、水不溶性葡聚糖合成能力具有显著抑制作用,在龋病防治方面具有极大的研究价值和前景<sup>[19]</sup>。

甜茶是一种甜味高、热量低的物质,甜茶的提取物甜茶素在甜味植物中口感极佳,甜茶中的主要二萜类化合物是甜茶素。目前对甜茶的化学成分以及其生物活性的研究较多,但对甜茶中二萜类的化合物的研究仅局限于甜茶素的活性研究,对其衍生物的研究报导的不多。二萜类化合物具有较好生物活性,例如抗病毒、抗炎、肿瘤、抗免疫等<sup>[20]</sup>。二萜类化合物有很多结构类型,由于产地的地理环境、生态环境和采集时间的不同,同一种植物中的二萜成分会有明显的差异,而这种结构类型的多变性导致了其药理学作用和生理活性的多样性。但到目前为止对生理活性的研究还有很多局限性,主要集中在消炎、抗菌、抗肿瘤以及体外细胞毒活性筛选等方面<sup>[21]</sup>,因此多靶点、多途径的研究思路将是今后研究的一个重要环节<sup>[22]</sup>。

目前,国内关于甜茶化学成分的研究内容主要是甜茶中多酚类、甜茶素以及黄酮类化合物的生物活性研究。甜茶具有广泛的药理活性,其中二萜类化合物结构丰富,生物活性显著。但目前对这些二萜类化合物的活性研究主要是少数单体化合物,主要有抗凝、抗炎、抗血小板聚集、胆碱酯酶抑制等生物活性。对于大多数二萜类化合物而言天然产物的量有限,导致对其生

物活性的研究很少。借鉴二萜类化合物的生物活性研究,可以对大瑶山甜茶的二萜类衍生物的降血压、抗菌、抗 HBV 病毒等进行多活性研究<sup>[23]</sup>。选择活性较好的二萜类为先导化合物进行结构改造<sup>[24]</sup>,增强其溶解性和活性,为将来活性更好的化合物的开发和利用奠定基础<sup>[25]</sup>。

本研究从大瑶山甜茶的正丁醇部位中共分离、鉴定出 10 种化合物,均为二萜类结构,分别为化合物 1-10。研究表明大瑶山甜茶中除甜茶素外还含有大量的该类型二萜类的衍生物,各种化合物具有不同的甜度,下一步工作是测试该类型二萜类化合物甜度,明确结构和甜度的关系,为结构修饰该类型化合物,找到甜度更大的化合物奠定基础。

总之,二萜类化合物是一类具有较强生物活性的天然产物,并且这类化合物大多数具有  $\alpha$ 、 $\beta$ - 不饱和双键结构片段。实验研究表明很多二萜类化合物具有较强的抗肿瘤活性,具有很好的研究前景和应用开发价值。我国幅员辽阔,含有二萜类化合物的生物资源非常丰富,开发该类活性成分作为降血压、抗肿瘤、治疗肝炎药物的前景十分广阔<sup>[26]</sup>。选择活性较好的二萜类化合物进行体外抗肿瘤活性的筛选,或者在保留原有药效基团的基础上进行结构修饰,合成系列衍生物,并研究其抗癌活性的构效关系<sup>[27]</sup>,从而得到期望的活性强、水溶性好的衍生物,对其衍生物进行在体动物实验证实体内药理学活性<sup>[28]</sup>,并运用分子生物学和细胞生物学技术研究其作用机制,有望得到作用机制明确、溶解性好、效率高、毒性低、有应用前景的候选药物,对寻找新的活性较好的药物具有重要指导意义<sup>[29]</sup>。

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