广东南药产业技术体系创新团队（广州中医药大学）在岭南道地药材广藿香的活性成分合成新机制取得系列新进展

广藿香具有芳香化浊，和中止呕，发表解暑的功效，是临床常用的芳香化湿药，在我国长期使用并已成为著名的岭南道地药材，列入首批立法保护的“粤八味”。此外，广藿香油被认为是非常重要的生物活性物质，广泛用于医药、化工、食品等行业和芳香疗法。原植物广藿香（*Pogostemon cablin*）富含挥发油，包括多种活性成分，例如倍半萜类、黄酮类和生物碱。其中广藿香醇作为天然倍半萜类化合物，被证明可缓解抑郁、压力、控制食欲并具有抗炎、抗伤害性和抗真菌等特性，是药材质量指标性物质。长期以来，由于种质、栽培及加工方式的影响，导致广藿香油质量产量不稳定。因此解析广藿香醇合成调控机制，不仅为利用代谢工程促进广藿香醇的生物合成提供科学依据，而且对提高广藿香油的质量产量具有重要意义。

近年来广东南药产业技术体系创新团队（广州中医药大学）、岭南中药资源资源教育部重点实验室詹若挺/陈立凯课题团队基于基因组- 转录组-蛋白质组解析了广藿香多组学遗传基础，揭示了广藿香醇生源合成完整通路基因（HORTIC RES, 2019；IND CROP PROD, 2019；BMC PLANT BIOL, 2019；BOT STUD, 2019），开展了系列广藿香种质资源的鉴定评价；围绕广藿香药效成分遗传调控进行深入研究，针对围绕茉莉酸途径介导参与控制广藿香醇合成下游基因转录，验证了JAZ6 蛋白的抑制功能（INT J MOL SCI, 2019）；围绕广藿香醇合酶（PatPTS）基因表达调控，首次克隆并分析了 *PatPTS* 基因启动子，并筛选鉴定了几个核心的转录调控因子，包括 PatSWC4、PatGT-1 等可以通过结合 *PatPTS* 基因启动子进行基因表达调节，继而影响广藿香醇的合成（IND CROP PROD, 2020；IND CROP PROD, 2021）。

近期团队筛选鉴定到一个受茉莉酸甲酯诱导的 AP2/ERF 转录因子 PatDREB，并揭示了该转录因子介导广藿香醇生物合成的分子机制，该研究结果以题为 PatDREB Transcription Factor Activates Patchoulol Synthase Gene Promoter and Positively Regulates Jasmonate-Induced Patchoulol Biosynthesis 发表在 **Journal of Agricultural and Food Chemistry** 上。研究发现 PatDREB 直接与 PatPTS 基因启动子结合并激活表达，促进广藿香醇的生物合成。此外，PatDREB 可与 PatJAZ4

茉莉酸 ZIM 域相结合。进一步实验表明 PatDREB 与 PatSWC4 发生蛋白互作，并且 PatJAZ4 可以抑制 PatDREB-PatSWC4 复合物的转录激活活性，协同促进广藿香醇的生物合成。

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PatDREB Transcription Factor Activates Patchoulol Synthase Gene Promoter and Positively Regulates Jasmonate-Induced Patchoulol Biosynthesis

Xiuzhen Chen, Xiaobing Wang, Daidi Wu, Junren Li, Huiling Huang, Xilin Wang, Ruoting Zhan,* and Likai Chen*

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通过挖掘研究还发现广藿香转录因子 PcbZIP44 能够直接与广藿香 *PcPTS* 启动子结合，并提出了一个 PcbZIP44 如何通过 *PcPTS* 基因和 MEP 途径负调节广藿香醇生物合成的工作模式。研究结果以题为 The PcbZIP44 transcription factor inhibits patchoulol synthase gene expression and negatively regulates patchoulol biosynthesis in *Pogostemon cablin* 发表在 **Industrial Crops& Products**。本研究该研究揭示了 PcbZIP44 转录因子抑制广藿香醇合酶基因启动子并负向调节广藿香醇生物合成的分子机制。

The PcbZIP44 transcription factor inhibits patchoulol synthase gene expression and negatively regulates patchoulol biosynthesis in *Pogostemon cablin*

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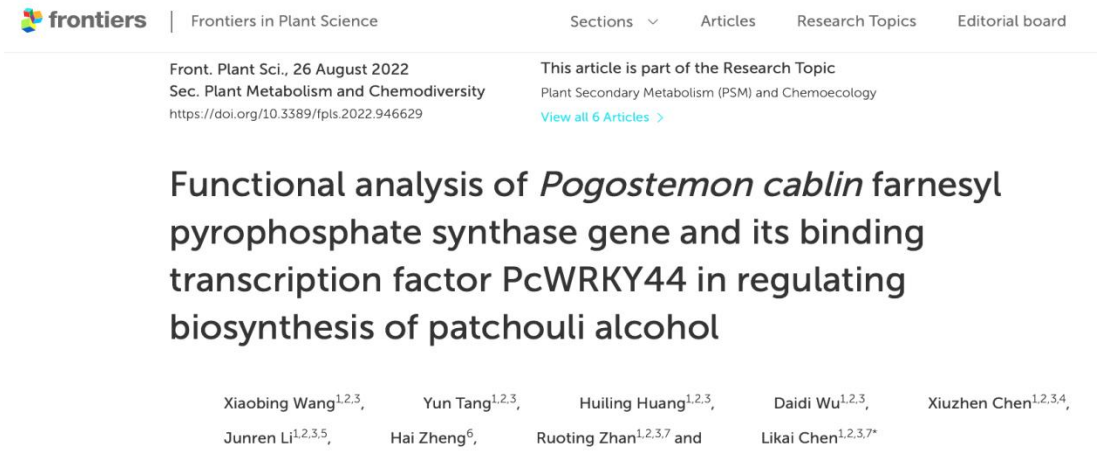
为了进一步完善广藿香醇合成调控网络，团队分离克隆了广藿香 FPP 合成酶基因的全长 cDNA，验证 FPPS 在广藿香醇等倍半萜生物合成中的功能；将 PcFPPS 启动子进行分析，筛选挖掘到一个与 PcFPPS 启动子结合的转录因子 PcWRKY44，并揭示了它们参与调控广藿香醇生物合成的功能。该研究结果以题为 Functional analysis of Pogostemon cablin farnesyl pyrophosphate synthase gene

and its binding transcription factor PcWRKY44 in regulating biosynthesis of patchouli alcohol 发表在 **Frontiers in Plant Science**。为深入研究广藿香醇合成酶功能基因和调控功能的转录因子和解析广藿香萜类合成机制奠定关键基础。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Functional analysis of *Pogostemon cablin* farnesyl pyrophosphate synthase gene and its binding transcription factor PcWRKY44 in regulating biosynthesis of patchouli alcohol

Xiaobing Wang[1,2,3], Yun Tang[1,2,3], Huiling Huang[1,2,3], Daidi Wu[1,2,3], Xiuzhen Chen[1,2,3,4], Junren Li[1,2,3,5], Hai Zheng[6], Ruoting Zhan[1,2,3,7] and Likai Chen[1,2,3,7*]

系列的研究进展不仅挖掘获得广藿香醇通路基因的关键调控因子，不断完善广藿香醇生物合成、广藿香油质量形成的分子调控机制，而且大大促进广藿香质量与植物生长发育、胁迫响应、代谢等相关联系的认识，为广藿香资源的可持续开发利用提供重要科学依据。

本研究得到了国家自然科学基金、广东省重点研发计划项目、广东省自然科学基金、省级乡村振兴战略专项、广州中医药大学“双一流”与高水平大学学科创新项目、广州中医药大学引进“杏林人才”等项目的资助。

附：近年发表的 10 篇相关学术论文

Huiling Huang; Daidi Wu; Taoyu Guo; Danhua Zhang; Xilin Wang; Jiexuan Zhuang; Xuan Zou; Lizhen Gong; Ruoting Zhan; Likai Chen; The PcbZIP44 transcription factor inhibits patchoulol synthase gene expression and negatively regulates patchoulol biosynthesis in Pogostemon cablin, *Industrial Crops and Products*, 2022, 188: 115561.

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