

· 资源与鉴定 ·

引种栝楼过氧化物同工酶分析

张荣超, 辛杰, 韩琳娜, 周凤琴*
(山东中医药大学药学院, 济南 250355)

[摘要] 目的:对国内不同产区栝楼进行种源间亲缘关系的分析。方法:采用聚丙烯酰胺凝胶电泳(PAGE)技术对不同种源栝楼过氧化物同工酶(POD)进行研究。结果:不同产区栝楼过氧化物同工酶在酶带数、迁移率和酶量等方面存在差异。栝楼 POD 酶谱共有 10 条谱带,分为 5 个类群, I, V 和其他 4 个类群亲缘关系都较远, II, III, IV 这 3 个类群的亲缘关系较近。结论:过氧化物同工酶谱可以作为不同种源栝楼遗传多样性鉴定的参考依据。

[关键词] 栝楼; 过氧化物同工酶; 聚丙烯酰胺凝胶电泳; 遗传多样性

[中图分类号] R282 **[文献标识码]** A **[文章编号]** 1005-9903(2013)20-0123-06

[doi] 10.11653/syfy2013200123

POD Isozyme Analysis of Introduced *Trichosanthes kirilowii* from Different Production Regions

ZHANG Rong-chao, XIN Jie, HAN Lin-na, ZHOU Feng-qin*

(Pharmacy College, Shandong University of Traditional Chinese Medicine, Ji'nan 250355, China)

[Abstract] **Objective:** To study the germplasm resources of *Trichosanthes kirilowii*. **Method:** The experiment was analyzed by using the technique of peroxidase (POD) isozyme. **Result:** The results show that obvious differences exist in the number of bands, Rf and amount of POD isozyme. The enzyme spectrum own 10 species, divided into five compartments. I and V are distantly related to other 3 species. II, III and IV are closed to each other. **Conclusion:** POD isozyme patterns can be a useful marker for genetic diversity of *T. kirilowii* from different regions.

[Key words] *Trichosanthes kirilowii*; peroxidase isozyme; polyacrylamide gel electrophoresis (PAGE); genetic diversity

栝楼为葫芦科栝楼属植物,果实入药称全栝楼、栝楼皮,种子入药称栝楼仁,块根入药称天花粉,是我国常用大宗药材之一。栝楼是雌雄异株植物,因此不同产区的栝楼在表型上均存在一定的差异,呈现出一定的遗传多样性。目前,有关栝楼的研究报

道数量众多,但多集中在化学、药理及临床应用等方面^[1],有关栝楼种质与良种选育的研究也仅仅开展了初步工作,对国内不同产区瓜蒌进行种质的区分和亲缘关系归纳目前尚无相关报道^[2]。

同工酶是基因表达的产物,特异的基因表达产生特异的同工酶酶谱。目前同工酶已被用于植物系统演化研究、种质资源的鉴定及亲缘关系的研究等方面,都取得了良好的效果^[3]。本文采用聚丙烯酰胺凝胶电泳,根据过氧化物同工酶相对分子质量的大小和所带电荷差异,进行不同栝楼种质之间的亲缘关系的鉴定。

2 材料和方法

2.1 药物 样品于 2011 年采自于全国 6 个瓜蒌产

[收稿日期] 20130112(005)

[基金项目] 国家科技支撑计划项目(2011BAI06B06);山东省科技发展计划项目(2011GSF11904)

[第一作者] 张荣超,硕士,从事中药质量与资源研究, Tel: 15254137669, E-mail: zhrnhchao@163.com

[通讯作者] *周凤琴,教授,博士生导师,从事中药鉴定学、中药商品学和中药资源学的教学与科研, Tel: 13553109263, E-mail: zfqsdzy@yahoo.com.cn

区,移栽于山东中医药大学植物园,见表 1。原植物经山东中医药大学周凤琴教授鉴定,确认为葫芦科栝楼属植物栝楼 *Trichosanthes kirilowii* Maxim.。

表 1 不同种源栝楼编号及采样信息

| No. | 品种 | 产地 | No. | 品种 | 产地 |
|-----|-----------|------|-----|---------|------|
| 1 | MSGLO01 | 山东长清 | 17 | 红大片 | 安徽潜山 |
| 2 | FCGL002 | 山东肥城 | 18 | 6号 | 安徽潜山 |
| 3 | FCGL004 | 山东肥城 | 19 | 红大片 | 安徽潜山 |
| 4 | MSGLO03 | 山东长清 | 20 | 黑片 | 安徽潜山 |
| 5 | MSGLO04 | 山东长清 | 21 | YXHP001 | 安徽潜山 |
| 6 | MSGLO05 | 山东长清 | 22 | 花皮瓜 | 安徽潜山 |
| 7 | AGGL001 | 河北安国 | 23 | YXHP002 | 安徽潜山 |
| 8 | AGGL002 | 河北安国 | 24 | 新平一号 | 安徽潜山 |
| 9 | AGGL005 | 河北安国 | 25 | 黄大片 | 安徽潜山 |
| 10 | BZNDGL001 | 安徽亳州 | 26 | PYGL003 | 山东平阴 |
| 11 | BZNDGL002 | 安徽亳州 | 27 | PYGL004 | 山东平阴 |
| 12 | BZNDGL003 | 安徽亳州 | 28 | PYGL013 | 山东平阴 |
| 13 | BZNDGL004 | 安徽亳州 | 29 | PYGL014 | 山东平阴 |
| 14 | 1号青瓜 | 安徽潜山 | 30 | PYGL015 | 山东平阴 |
| 15 | 皖菱三号 | 安徽潜山 | 31 | PYGL026 | 山东平阴 |
| 16 | 大麻子 | 安徽潜山 | | | |

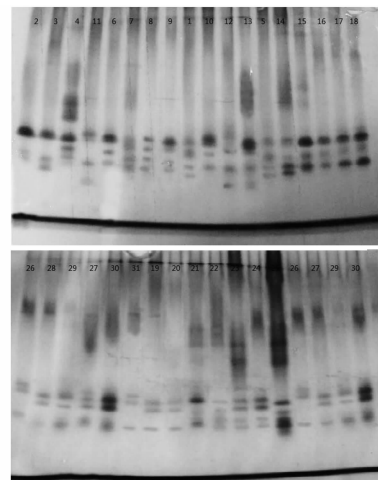
2.2 电泳 采用双面垂直板聚丙烯酰胺凝胶电泳,10%分离胶,3%浓缩胶。每孔点样约 30 μ L,在稳流条件下调至 30 mA,使样品进入凝胶,待指示剂到达分离胶与浓缩胶界面时,调电流至 60 mA^[4-10]。

2.3 供试品的制备 分别取 0.5 g 样品放入研钵中,取 1 mL 浓缩胶缓冲液稀释 4 倍加入研钵中,冰浴研磨,冰浴超声 15 min,10 000 $r \cdot \text{min}^{-1}$,离心 15 min 取上清,加入等体积的 40% 蔗糖溶液混匀,4 $^{\circ}\text{C}$ 冰箱储存备用^[11]。

2.4 染色 醋酸联苯胺染色法,不断搅动,各条带显色后,拍照,保存于 7% 醋酸中,见图 1。

3 结果与分析

3.1 不同种源栝楼过氧化物酶同工酶图谱分析 不同种源栝楼过氧化物酶同工酶图谱见图 1,酶带的相对迁移率(Rf) = 酶带的迁移距离/溴酚蓝的迁移距离,见表 2。从图 1、表 2 可知,不同种源栝楼过氧化物酶同工酶图谱共有 10 条谱带,可分为 2 个酶区,第 I 酶区有 4 条带,相对迁移率在 0.409 ~ 0.636;第 II 酶区有 5 条带,相对迁移率在 0.664 ~ 0.845。不同种源栝楼过氧化物酶同工酶在酶带数目、酶带着色深浅、酶带迁移率及酶活性等方面存在比较明显的差异。



a. 种 A 在酶谱中的酶带数;b. 种 B 在酶谱中的酶带数,
ω. A,B 两个种相同的酶带数

图 1 不同种源栝楼过氧化物酶同工酶图谱

3.2 不同种源栝楼过氧化物酶同工酶亲缘关系分析 用酶谱间相似系数(similarity coefficient)的大小表示分类群亲缘关系的远近,用不相似系数和酶谱距离作为表征两分类群分歧的数量指标。具体方法:分别计算不同种源栝楼过氧化物酶同工酶酶谱相似系数(c),构成一个矩阵,结果见表 3。

$$c = \frac{2\omega}{a + b}$$

计算每一个种与其余种源两两之间的不相似系数(d), $d = 100 - c$,见表 4。

计算每一种质与其他种质的不相似系数的总和,填入表 3。

确定各个种质酶谱在 x 轴上的位置。把不相似总和最大的 12 号种质作为 A 标记在 x 轴上的 0 位置,找出与 12 号种质最不相似的 26,28,30,31 号种质标记在 x 轴的另一端,作为 B。其余种质酶谱沿 x 轴对狭叶种质的酶谱距离(X_i),可由下式计算出:

$$X_i = \frac{L^2 + D_a^2 - D_b^2}{2L}$$

式中 X_i 为所求种的酶谱沿 x 轴对种 A 酶谱的距离; L 为种 A 的 a 与种 B 的 b 之间的不相似值; D_a 为种 A 的 a 与所求酶谱之间的不相似值; D_b 为种 B 的 b 与所求酶谱之间的不相似值。

将不同种源栝楼过氧化物酶同工酶谱在 x 轴上排序,所得结果见图 2。

从图 2 中可以看出,不同种源栝楼过氧化物酶同工酶谱上分析,共分为 5 个类群,分别为 I, II, III, IV, V, I 为 12,10, II 为 2,3,11,13,16,17,18, III 为 1,5,6,8,9,15,21,22,25,4,7,23,24,27,14, IV 为 19,20,29, V 为 26,28,30,31。I, V 和其他 4 个

表2 不同种源栝楼过氧化物同工酶带的相对迁移率

| 种源 | 迁移率 Rf | | | | | | | | |
|----|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑨ |
| 1 | | | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 2 | | | | | 0.664 | | 0.745 | 0.782 | |
| 3 | | | | | 0.664 | | 0.745 | 0.782 | |
| 4 | | 0.518 | 0.591 | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 5 | | | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 6 | | | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 7 | | 0.518 | 0.591 | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 8 | | | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 9 | | | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 10 | | | | 0.636 | 0.664 | | 0.745 | | |
| 11 | | | | 0.636 | 0.664 | 0.691 | | 0.782 | 0.845 |
| 12 | | | | 0.636 | 0.664 | | 0.745 | | 0.845 |
| 13 | 0.409 | 0.518 | | | 0.664 | 0.691 | 0.745 | | 0.845 |
| 14 | 0.409 | 0.518 | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 15 | 0.409 | 0.518 | | | 0.664 | 0.691 | 0.745 | | |
| 16 | | | | | 0.664 | 0.691 | 0.745 | | |
| 17 | | | | | 0.664 | 0.691 | 0.745 | | |
| 18 | | | | | 0.664 | 0.691 | 0.745 | | |
| 19 | | | | | 0.664 | 0.691 | | 0.782 | |
| 20 | | | | | 0.664 | 0.691 | | 0.782 | |
| 21 | 0.409 | 0.518 | | | 0.664 | | 0.745 | 0.782 | |
| 22 | 0.409 | 0.518 | | | 0.664 | | 0.745 | 0.782 | |
| 23 | | 0.518 | 0.591 | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 24 | 0.409 | | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 25 | 0.409 | 0.518 | 0.591 | | | 0.691 | 0.745 | 0.782 | 0.845 |
| 26 | 0.409 | | | | 0.664 | 0.691 | | 0.782 | |
| 28 | 0.409 | | | | 0.664 | 0.691 | | 0.782 | |
| 27 | 0.409 | | | | 0.664 | 0.691 | 0.745 | 0.782 | |
| 29 | 0.000 | | | | 0.664 | 0.691 | | 0.782 | |
| 30 | 0.409 | | | | 0.664 | 0.691 | | 0.782 | |
| 31 | 0.409 | | | | 0.664 | 0.691 | | 0.782 | |

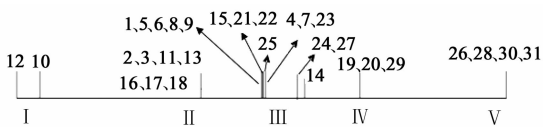


图2 不同种源栝楼过氧化物同工酶谱在x轴上的排序

类群亲缘关系都较远, II, III, IV 这3个类群的亲缘关系较近, 其中, 有些种源的过氧化物同工酶图谱相

同, 因此在x轴上的位置一样。

4 讨论

过氧化物同工酶是由单基因决定的同工酶, 能较好地反映不同种质间的遗传差异和亲缘关系。从供试材料的POD酶谱分析可以看出, 不同种源栝楼过氧化物酶同工酶在酶带数、迁移率和酶量等方面存在比较明显的差异, 表明其具有丰富的遗传多样

表 3 不同种源栝楼过氧化物同工酶谱间相似系数

| No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|-----|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|--------|
| 1 | | | | | | | | | | | | | | | | |
| 2 | 85.71 | | | | | | | | | | | | | | | |
| 3 | 85.71 | 100.00 | | | | | | | | | | | | | | |
| 4 | 80.00 | 66.67 | 66.67 | | | | | | | | | | | | | |
| 5 | 100.00 | 85.71 | 85.71 | 80.00 | | | | | | | | | | | | |
| 6 | 100.00 | 85.71 | 85.71 | 80.00 | 100.00 | | | | | | | | | | | |
| 7 | 80.00 | 66.67 | 66.67 | 100.00 | 80.00 | 80.00 | | | | | | | | | | |
| 8 | 100.00 | 85.71 | 85.71 | 80.00 | 100.00 | 100.00 | 80.00 | | | | | | | | | |
| 9 | 100.00 | 85.71 | 85.71 | 80.00 | 100.00 | 100.00 | 80.00 | 100.00 | | | | | | | | |
| 10 | 57.14 | 66.67 | 66.67 | 44.44 | 57.14 | 57.14 | 44.44 | 57.14 | 57.14 | | | | | | | |
| 11 | 66.67 | 50.00 | 50.00 | 54.55 | 66.67 | 66.67 | 54.55 | 66.67 | 66.67 | 50.00 | | | | | | |
| 12 | 50.00 | 57.14 | 57.14 | 40.00 | 50.00 | 50.00 | 40.00 | 50.00 | 50.00 | 85.71 | 66.67 | | | | | |
| 13 | 60.00 | 44.44 | 44.44 | 66.67 | 60.00 | 60.00 | 66.67 | 60.00 | 60.00 | 44.44 | 54.55 | 60.00 | | | | |
| 14 | 80.00 | 66.67 | 66.67 | 83.33 | 80.00 | 80.00 | 83.33 | 80.00 | 80.00 | 44.44 | 54.55 | 40.00 | 83.33 | | | |
| 15 | 66.67 | 50.00 | 50.00 | 72.73 | 66.67 | 66.67 | 72.73 | 66.67 | 66.67 | 50.00 | 40.00 | 44.44 | 90.91 | 90.91 | | |
| 16 | 85.71 | 66.67 | 66.67 | 66.67 | 85.71 | 85.71 | 66.67 | 85.71 | 85.71 | 66.67 | 50.00 | 57.14 | 66.67 | 66.67 | 75.00 | |
| 17 | 85.71 | 66.67 | 66.67 | 66.67 | 85.71 | 85.71 | 66.67 | 85.71 | 85.71 | 66.67 | 50.00 | 57.14 | 66.67 | 66.67 | 75.00 | 100.00 |
| 18 | 85.71 | 66.67 | 66.67 | 66.67 | 85.71 | 85.71 | 66.67 | 85.71 | 85.71 | 66.67 | 50.00 | 57.14 | 66.67 | 66.67 | 75.00 | 100.00 |
| 19 | 85.71 | 66.67 | 66.67 | 66.67 | 85.71 | 85.71 | 66.67 | 85.71 | 85.71 | 33.33 | 75.00 | 28.57 | 44.44 | 66.67 | 50.00 | 66.67 |
| 20 | 85.71 | 66.67 | 66.67 | 66.67 | 85.71 | 85.71 | 66.67 | 85.71 | 85.71 | 33.33 | 75.00 | 28.57 | 44.44 | 66.67 | 50.00 | 66.67 |
| 21 | 66.67 | 75.00 | 75.00 | 72.73 | 66.67 | 66.67 | 72.73 | 66.67 | 66.67 | 50.00 | 40.00 | 44.44 | 72.73 | 90.91 | 80.00 | 50.00 |
| 22 | 66.67 | 75.00 | 75.00 | 72.73 | 66.67 | 66.67 | 72.73 | 66.67 | 66.67 | 50.00 | 40.00 | 44.44 | 72.73 | 90.91 | 80.00 | 50.00 |
| 23 | 80.00 | 66.67 | 66.67 | 100.00 | 80.00 | 80.00 | 100.00 | 80.00 | 80.00 | 44.44 | 54.55 | 40.00 | 66.67 | 83.33 | 72.73 | 66.67 |
| 24 | 88.89 | 75.00 | 75.00 | 72.73 | 88.89 | 88.89 | 72.73 | 88.89 | 88.89 | 50.00 | 60.00 | 44.44 | 72.73 | 90.91 | 80.00 | 75.00 |
| 25 | 54.55 | 40.00 | 40.00 | 76.92 | 54.55 | 54.55 | 76.92 | 54.55 | 54.55 | 20.00 | 50.00 | 36.36 | 76.92 | 76.92 | 66.67 | 40.00 |
| 26 | 75.00 | 57.14 | 57.14 | 60.00 | 75.00 | 75.00 | 60.00 | 75.00 | 75.00 | 28.57 | 66.67 | 25.00 | 60.00 | 80.00 | 66.67 | 57.14 |
| 27 | 88.89 | 75.00 | 75.00 | 72.73 | 88.89 | 88.89 | 72.73 | 88.89 | 88.89 | 50.00 | 60.00 | 44.44 | 72.73 | 90.91 | 80.00 | 75.00 |
| 28 | 75.00 | 57.14 | 57.14 | 60.00 | 75.00 | 75.00 | 60.00 | 75.00 | 75.00 | 28.57 | 66.67 | 25.00 | 60.00 | 80.00 | 66.67 | 57.14 |
| 29 | 85.71 | 66.67 | 66.67 | 66.67 | 85.71 | 85.71 | 66.67 | 85.71 | 85.71 | 33.33 | 75.00 | 28.57 | 44.44 | 66.67 | 50.00 | 66.67 |
| 30 | 75.00 | 57.14 | 57.14 | 60.00 | 75.00 | 75.00 | 60.00 | 75.00 | 75.00 | 28.57 | 66.67 | 25.00 | 60.00 | 80.00 | 66.67 | 57.14 |
| 31 | 75.00 | 57.14 | 57.14 | 60.00 | 75.00 | 75.00 | 60.00 | 75.00 | 75.00 | 28.57 | 66.67 | 25.00 | 60.00 | 80.00 | 66.67 | 57.14 |
| No. | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | | |
| 18 | 100.00 | | | | | | | | | | | | | | | |
| 19 | 66.67 | 66.67 | | | | | | | | | | | | | | |
| 20 | 66.67 | 66.67 | 100.00 | | | | | | | | | | | | | |
| 21 | 50.00 | 50.00 | 50.00 | 50.00 | | | | | | | | | | | | |
| 22 | 50.00 | 50.00 | 50.00 | 50.00 | 100.00 | | | | | | | | | | | |
| 23 | 66.67 | 66.67 | 66.67 | 66.67 | 72.23 | 72.23 | | | | | | | | | | |
| 24 | 75.00 | 75.00 | 75.00 | 75.00 | 80.00 | 80.00 | 72.73 | | | | | | | | | |
| 25 | 40.00 | 40.00 | 40.00 | 40.00 | 66.67 | 66.67 | 76.92 | 66.67 | | | | | | | | |
| 26 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | 60.00 | 88.89 | 54.55 | | | | | | | |

续表 3

| No. | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|-----|-------|-------|--------|--------|-------|-------|-------|--------|-------|--------|-------|--------|-------|--------|
| 27 | 75.00 | 75.00 | 75.00 | 75.00 | 80.00 | 80.00 | 72.73 | 100.00 | 66.67 | 88.89 | | | | |
| 28 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | 60.00 | 88.89 | 54.55 | 100.00 | 88.89 | | | |
| 29 | 66.67 | 66.67 | 100.00 | 100.00 | 50.00 | 50.00 | 66.67 | 75.00 | 40.00 | 85.71 | 75.00 | 85.71 | | |
| 30 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | 60.00 | 88.89 | 54.55 | 100.00 | 88.89 | 100.00 | 85.71 | |
| 31 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | 60.00 | 88.89 | 54.55 | 100.00 | 88.89 | 100.00 | 85.71 | 100.00 |

表 4 不同种源栝楼过氧化物同工酶谱间不相似值总和与 X_i 值

| No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | | 14.29 | 14.29 | 20.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 42.86 | 33.33 | 50.00 | 40.00 | 20.00 | 33.33 | 14.29 |
| 2 | 14.29 | | 0.00 | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 33.33 | 50.00 | 42.86 | 55.56 | 33.33 | 50.00 | 33.33 |
| 3 | 14.29 | 0.00 | | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 33.33 | 50.00 | 42.86 | 55.56 | 33.33 | 50.00 | 33.33 |
| 4 | 20.00 | 33.33 | 33.33 | | 20.00 | 20.00 | 0.00 | 20.00 | 20.00 | 55.56 | 45.45 | 60.00 | 33.33 | 16.67 | 27.27 | 33.33 |
| 5 | 0.00 | 14.29 | 14.29 | 20.00 | | 0.00 | 20.00 | 0.00 | 0.00 | 42.86 | 33.33 | 50.00 | 40.00 | 20.00 | 33.33 | 14.29 |
| 6 | 0.00 | 14.29 | 14.29 | 20.00 | 0.00 | | 20.00 | 0.00 | 0.00 | 42.86 | 33.33 | 50.00 | 40.00 | 20.00 | 33.33 | 14.29 |
| 7 | 20.00 | 33.33 | 33.33 | 0.00 | 20.00 | 20.00 | | 20.00 | 20.00 | 55.56 | 45.45 | 60.00 | 33.33 | 16.67 | 27.27 | 33.33 |
| 8 | 0.00 | 14.29 | 14.29 | 20.00 | 0.00 | 0.00 | 20.00 | | 0.00 | 42.86 | 33.33 | 50.00 | 40.00 | 20.00 | 33.33 | 14.29 |
| 9 | 0.00 | 14.29 | 14.29 | 20.00 | 0.00 | 0.00 | 20.00 | 0.00 | | 42.86 | 33.33 | 50.00 | 40.00 | 20.00 | 33.33 | 14.29 |
| 10 | 42.86 | 33.33 | 33.33 | 55.56 | 42.86 | 42.86 | 55.56 | 42.86 | 42.86 | | 50.00 | 14.29 | 55.56 | 55.56 | 50.00 | 33.33 |
| 11 | 33.33 | 50.00 | 50.00 | 45.45 | 33.33 | 33.33 | 45.45 | 33.33 | 33.33 | 50.00 | | 33.33 | 45.45 | 45.45 | 60.00 | 50.00 |
| 12 | 50.00 | 42.86 | 42.86 | 60.00 | 50.00 | 50.00 | 60.00 | 50.00 | 50.00 | 14.29 | 33.33 | | 40.00 | 60.00 | 55.56 | 42.86 |
| 13 | 40.00 | 55.56 | 55.56 | 33.33 | 40.00 | 40.00 | 33.33 | 40.00 | 40.00 | 55.56 | 45.45 | 40.00 | | 16.67 | 9.09 | 33.33 |
| 14 | 20.00 | 33.33 | 33.33 | 16.67 | 20.00 | 20.00 | 16.67 | 20.00 | 20.00 | 55.56 | 45.45 | 60.00 | 16.67 | | 9.09 | 33.33 |
| 15 | 33.33 | 50.00 | 50.00 | 27.27 | 33.33 | 33.33 | 27.27 | 33.33 | 33.33 | 50.00 | 60.00 | 55.56 | 9.09 | 9.09 | | 25.00 |
| 16 | 14.29 | 33.33 | 33.33 | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 33.33 | 50.00 | 42.86 | 33.33 | 33.33 | 25.00 | |
| 17 | 14.29 | 33.33 | 33.33 | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 33.33 | 50.00 | 42.86 | 33.33 | 33.33 | 25.00 | 0.00 |
| 18 | 14.29 | 33.33 | 33.33 | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 33.33 | 50.00 | 42.86 | 33.33 | 33.33 | 25.00 | 0.00 |
| 19 | 14.29 | 33.33 | 33.33 | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 66.67 | 25.00 | 71.43 | 55.56 | 33.33 | 50.00 | 33.33 |
| 20 | 14.29 | 33.33 | 33.33 | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 66.67 | 25.00 | 71.43 | 55.56 | 33.33 | 50.00 | 33.33 |
| 21 | 33.33 | 25.00 | 25.00 | 27.27 | 33.33 | 33.33 | 27.27 | 33.33 | 33.33 | 50.00 | 60.00 | 55.56 | 27.27 | 9.09 | 20.00 | 50.00 |
| 22 | 33.33 | 25.00 | 25.00 | 27.27 | 33.33 | 33.33 | 27.27 | 33.33 | 33.33 | 50.00 | 60.00 | 55.56 | 27.27 | 9.09 | 20.00 | 50.00 |
| 23 | 20.00 | 33.33 | 33.33 | 0.00 | 20.00 | 20.00 | 0.00 | 20.00 | 20.00 | 55.56 | 45.45 | 60.00 | 33.33 | 16.67 | 27.27 | 33.33 |
| 24 | 11.11 | 25.00 | 25.00 | 27.27 | 11.11 | 11.11 | 27.27 | 11.11 | 11.11 | 50.00 | 40.00 | 55.56 | 27.27 | 9.09 | 20.00 | 25.00 |
| 25 | 45.45 | 60.00 | 60.00 | 23.08 | 45.45 | 45.45 | 23.08 | 45.45 | 45.45 | 80.00 | 50.00 | 63.64 | 23.08 | 23.08 | 33.33 | 60.00 |
| 26 | 25.00 | 42.86 | 42.86 | 40.00 | 25.00 | 25.00 | 40.00 | 25.00 | 25.00 | 71.43 | 33.33 | 75.00 | 40.00 | 20.00 | 33.33 | 42.86 |
| 27 | 11.11 | 25.00 | 25.00 | 27.27 | 11.11 | 11.11 | 27.27 | 11.11 | 11.11 | 50.00 | 40.00 | 55.56 | 27.27 | 9.09 | 20.00 | 25.00 |
| 28 | 25.00 | 42.86 | 42.86 | 40.00 | 25.00 | 25.00 | 40.00 | 25.00 | 25.00 | 71.43 | 33.33 | 75.00 | 40.00 | 20.00 | 33.33 | 42.86 |
| 29 | 14.29 | 33.33 | 33.33 | 33.33 | 14.29 | 14.29 | 33.33 | 14.29 | 14.29 | 66.67 | 25.00 | 71.43 | 55.56 | 33.33 | 50.00 | 33.33 |
| 30 | 25.00 | 42.86 | 42.86 | 40.00 | 25.00 | 25.00 | 40.00 | 25.00 | 25.00 | 71.43 | 33.33 | 75.00 | 40.00 | 20.00 | 33.33 | 42.86 |
| 31 | 25.00 | 42.86 | 42.86 | 40.00 | 25.00 | 25.00 | 40.00 | 25.00 | 25.00 | 71.43 | 33.33 | 75.00 | 40.00 | 20.00 | 33.33 | 42.86 |

| No. | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | Σ | X_i |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|-------|
| 1 | 14.29 | 14.29 | 14.29 | 14.29 | 33.33 | 33.33 | 20.00 | 11.11 | 45.45 | 25.00 | 11.11 | 25.00 | 14.29 | 25.00 | 25.00 | 326.78 | 50.00 |
| 2 | 33.33 | 33.33 | 33.33 | 33.33 | 25.00 | 25.00 | 33.33 | 25.00 | 60.00 | 42.86 | 25.00 | 42.86 | 33.33 | 42.86 | 42.86 | 533.42 | 37.50 |
| 3 | 33.33 | 33.33 | 33.33 | 33.33 | 25.00 | 25.00 | 33.33 | 25.00 | 60.00 | 42.86 | 25.00 | 42.86 | 33.33 | 42.86 | 42.86 | 534.42 | 37.50 |
| 4 | 33.33 | 33.33 | 33.33 | 33.33 | 27.27 | 27.27 | 0.00 | 27.27 | 23.08 | 40.00 | 27.27 | 40.00 | 33.33 | 40.00 | 40.00 | 576.81 | 50.83 |
| 5 | 14.29 | 14.29 | 14.29 | 14.29 | 33.33 | 33.33 | 20.00 | 11.11 | 45.45 | 25.00 | 11.11 | 25.00 | 14.29 | 25.00 | 25.00 | 330.78 | 50.00 |
| 6 | 14.29 | 14.29 | 14.29 | 14.29 | 33.33 | 33.33 | 20.00 | 11.11 | 45.45 | 25.00 | 11.11 | 25.00 | 14.29 | 25.00 | 25.00 | 331.78 | 50.00 |
| 7 | 33.33 | 33.33 | 33.33 | 33.33 | 27.27 | 27.27 | 0.00 | 27.27 | 23.08 | 40.00 | 27.27 | 40.00 | 33.33 | 40.00 | 40.00 | 465.81 | 50.83 |
| 8 | 14.29 | 14.29 | 14.29 | 14.29 | 33.33 | 33.33 | 20.00 | 11.11 | 45.45 | 25.00 | 11.11 | 25.00 | 14.29 | 25.00 | 25.00 | 333.78 | 50.00 |
| 9 | 14.29 | 14.29 | 14.29 | 14.29 | 33.33 | 33.33 | 20.00 | 11.11 | 45.45 | 25.00 | 11.11 | 25.00 | 14.29 | 25.00 | 25.00 | 334.78 | 50.00 |

续表 4

| No. | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | Σ | X_i |
|-----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 10 | 33.33 | 33.33 | 66.67 | 66.67 | 50.00 | 50.00 | 55.56 | 50.00 | 80.00 | 71.43 | 50.00 | 71.43 | 66.67 | 71.43 | 71.43 | 897.95 | 4.85 |
| 11 | 50.00 | 50.00 | 25.00 | 25.00 | 60.00 | 60.00 | 45.45 | 40.00 | 50.00 | 33.33 | 40.00 | 33.33 | 25.00 | 33.33 | 33.33 | 614.77 | 37.50 |
| 12 | 42.86 | 42.86 | 71.43 | 71.43 | 55.56 | 55.56 | 60.00 | 55.56 | 63.64 | 75.00 | 55.56 | 75.00 | 71.43 | 75.00 | 75.00 | 957.89 | 0.00 |
| 13 | 33.33 | 33.33 | 55.56 | 55.56 | 27.27 | 27.27 | 33.33 | 27.27 | 23.08 | 40.00 | 27.27 | 40.00 | 55.56 | 40.00 | 40.00 | 571.83 | 37.50 |
| 14 | 33.33 | 33.33 | 33.33 | 33.33 | 9.09 | 9.09 | 16.67 | 9.09 | 23.08 | 20.00 | 9.09 | 20.00 | 33.33 | 20.00 | 20.00 | 336.76 | 58.83 |
| 15 | 25.00 | 25.00 | 50.00 | 50.00 | 20.00 | 20.00 | 27.27 | 20.00 | 33.33 | 33.33 | 20.00 | 33.33 | 50.00 | 33.33 | 33.33 | 488.92 | 50.67 |
| 16 | 0.00 | 0.00 | 33.33 | 33.33 | 50.00 | 50.00 | 33.33 | 25.00 | 60.00 | 42.86 | 25.00 | 42.86 | 33.33 | 42.86 | 42.86 | 530.76 | 37.50 |
| 17 | | 0.00 | 33.33 | 33.33 | 50.00 | 50.00 | 33.33 | 25.00 | 60.00 | 42.86 | 25.00 | 42.86 | 33.33 | 42.86 | 42.86 | 531.76 | 37.50 |
| 18 | 50.00 | | 33.33 | 33.33 | 50.00 | 50.00 | 33.33 | 25.00 | 60.00 | 42.86 | 25.00 | 42.86 | 33.33 | 42.86 | 42.86 | 582.76 | 37.50 |
| 19 | 50.00 | 50.00 | | 0.00 | 50.00 | 50.00 | 33.33 | 25.00 | 60.00 | 14.29 | 25.00 | 14.29 | 0.00 | 14.29 | 14.29 | 419.49 | 70.15 |
| 20 | 66.67 | 66.67 | 66.67 | | 50.00 | 50.00 | 33.33 | 25.00 | 60.00 | 14.29 | 25.00 | 14.29 | 0.00 | 14.29 | 14.29 | 520.50 | 70.15 |
| 21 | 75.00 | 75.00 | 75.00 | 75.00 | | 0.00 | 27.77 | 20.00 | 33.33 | 33.33 | 20.00 | 33.33 | 50.00 | 33.33 | 33.33 | 719.42 | 50.67 |
| 22 | 40.00 | 40.00 | 40.00 | 40.00 | 66.67 | | 27.77 | 20.00 | 33.33 | 33.33 | 20.00 | 33.33 | 50.00 | 33.33 | 33.33 | 533.09 | 50.67 |
| 23 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | | 27.27 | 23.08 | 40.00 | 27.27 | 40.00 | 33.33 | 40.00 | 40.00 | 712.99 | 50.83 |
| 24 | 75.00 | 75.00 | 75.00 | 75.00 | 80.00 | 80.00 | 72.73 | | 33.33 | 11.11 | 0.00 | 11.11 | 25.00 | 11.11 | 11.11 | 659.50 | 57.26 |
| 25 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | 60.00 | 88.89 | | 45.45 | 33.33 | 45.45 | 60.00 | 45.45 | 45.45 | 868.06 | 50.73 |
| 26 | 66.67 | 66.67 | 100.00 | 100.00 | 50.00 | 50.00 | 66.67 | 75.00 | 40.00 | | 11.11 | 0.00 | 14.29 | 0.00 | 0.00 | 666.41 | 100.00 |
| 27 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | 60.00 | 88.89 | 54.55 | 100.00 | | 11.11 | 25.00 | 11.11 | 11.11 | 807.81 | 57.26 |
| 28 | 57.14 | 57.14 | 85.71 | 85.71 | 66.67 | 66.67 | 60.00 | 88.89 | 54.55 | 100.00 | 88.89 | | 14.29 | 0.00 | 0.00 | 853.66 | 100.00 |
| 29 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | | 14.29 | 14.29 | 1257.5 | 70.15 |
| 30 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | | 100.00 | 1430.0 | 100.00 |
| 31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | | 1431.0 | 100.00 |

性。其中 12 号与其他不同种质的不相似值最大；Ⅱ,Ⅲ,Ⅳ这 3 个类群的亲缘关系较近,2,3,11,13,16,17,18;1,5,6,8,9;15,21,22;4,7,23;24,27;19,20,29;26,28,30,31 的酶谱特征分别完全相同。

由于栝楼是雌雄异株植物,进行授粉时会导致不同产区的栝楼在表型上均存在一定的差异,呈现出一定的遗传多样性。采用聚丙烯酰胺凝胶电泳,首次进行了不同种源栝楼的亲缘关系鉴定和种质的区分规划,为以后栝楼种质的筛选和药材的质量评价提供基础的研究和依据。

[参考文献]

[1] 龙凤来,胡普辉,黄时伟. 栝楼属植物研究进展[J]. 陕西林业科技,2008,36(2):58.
 [2] 屠婕红,余菁,陈伟光. 瓜蒌的化学成分和药理作用研究概况[J]. 中国药师,2004,7(7):562.
 [3] 朱新产,张庭荣,王宝维. 同工酶电泳资料评估与应用[J]. 自然杂志,2004,26(6):318.

[4] 孙稚颖,李恩波,周凤琴. 山东农家栽培瓜蒌品种的同工酶研究[J]. 中药材,2005,28(10):863.
 [5] 杨弘诣,赵文,李裕伟,等. 3 个不同养殖群体裙带菜同工酶的电泳分析[J]. 大连水产学院学报,2006,21(1):59.
 [6] 谢果珍. 不同居群栝楼遗传多样性的研究[D]. 武汉:华中农业大学,2012.
 [7] 赵晓平,荣威恒,王福喜,等. 两不同枣树品种的同工酶分析[J]. 河南农业科学,2008,23(6):85.
 [8] 张海利,陈勇兵,徐坚,等. 利用 POD 同工酶电泳对辣椒进行分类[J]. 安徽农业科学,2008,36(21):8952.
 [9] 司红起,马传喜,卢杰. 小麦籽粒萌发过程中 PPO 活性变化及同工酶电泳分析[J]. 种子,2009,28(9):4.
 [10] 郑伟华,王富兰,陈贺. 用同工酶电泳快速鉴定甜瓜品种的真实性与纯度研究[J]. 种子科技,2010,28(9):28.
 [11] 韩琳娜,周凤琴. 不同引种紫锥菊的过氧化物同工酶分析[J]. 四川农业大学学报,2011,29(3):52.

[责任编辑 邹晓翠]