

‘南果梨’及其芽变‘南红梨’果实中糖分积累与相关基因表达差异分析

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摘 要:【目的】对‘南果梨’及其芽变‘南红梨’果实发育期间的可溶性糖含量及糖代谢相关基因的表达量进行分析, 探索‘南果梨’及‘南红梨’糖积累差异的分子机制。【方法】以‘南果梨’及‘南红梨’果实为试材, 利用高效液相色谱对2者可溶性糖含量进行测定, qRT-PCR对蔗糖代谢关键基因中性转化酶(NI)、蔗糖磷酸合成酶(PS)及蔗糖合成酶(SS)的表达差异进行分析。【结果】‘南果梨’与‘南红梨’中的果糖含量均在果实发育后期(8月21日)达到最大值, 而‘南果梨’与‘南红梨’果实中葡萄糖与山梨醇含量差异不明显。果实发育初期, 2者蔗糖含量差异不明显, 采收期(9月14日)‘南红梨’果实中蔗糖含量约为‘南果梨’果实的2倍。PuNI与PuSS3在‘南果梨’中的表达量显著高于‘南红梨’, 而PuPS1、PuSS1和PuSS2在‘南红梨’中的表达量则高于‘南果梨’。【结论】‘南果梨’及‘南红梨’果实发育过程中糖代谢相关基因的差异表达会导致不同糖分的积累量出现差异。

关键词:‘南果梨’; ‘南红梨’; 蔗糖; 中性转化酶; 蔗糖合成酶; 蔗糖磷酸合成酶

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Differences in sugar accumulation and the related gene expression in fruit development between ‘Nanguo’ and its mutant ‘Nanhong’ pears

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Abstract:【Objective】‘Nanhong’ pear is a bud mutation of the ‘Nanguo’ pear and has been released as a new pear cultivar. The soluble sugars, especially sucrose, play important roles in many physiological pathways, such as fruit ripening and resistance. Here we aim to analyze the contents of soluble solids and major soluble sugars in ‘Nanguo’ and ‘Nanhong’ pear (*Pyrus ussuriensis* Maxim.) fruits and the expression profiles of sugar metabolism-related genes during fruit development. By doing this, we hope to clarify the relationship between soluble sugars and their related genes, providing some additional evidence for explaining the mechanism of why ‘Nanguo’ and ‘Nanhong’ pears show sugar accumulation mechanisms.【Methods】We measured the soluble sugar content by utilizing HPLC (High Performance Liquid Chromatography). By using the NCBI (National Center for Biotechnology Information) database and pear genome, we obtained the sequences of key genes involved in sugar metabolism. Then we designed specific primers and analyzed the expression profiles of these key genes in the ‘Nanguo’ and ‘Nanhong’ pears utilizing qRT-PCR (Quantitative real time polymerase chain reaction).【Results】The ‘Nanhong’ pear is a bud mutation of the ‘Nanguo’ pear. The pericarp of the ‘Nanhong’ pear fruits turn red at the late development stage, which is very popular in the marketplace and can be sold quickly. As a bud mutation of the ‘Nanguo’ pear, most of the main characteristics of the ‘Nanhong’ pear, such as the phonological period and

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the adaptability, are similar to the ‘Nanguo’ pear. Here we analyzed the soluble sugar contents of the ‘Nanguo’ and ‘Nanhong’ pear and observed the expression profiles of the genes involved in sugar metabolism. The soluble solid contents of the ‘Nanhong’ pear are different from the ‘Nanguo’ pear during fruit development: the contents of the ‘Nanguo’ pear reached its highest point before harvest (15.33%) and then declined a little on the harvest day; while the ‘Nanhong’ pear reached the highest point at its harvest day (16.06), which is higher than the ‘Nanguo’ pear. The contents of fructose, glucose, sucrose and sorbitol also showed different trends during the ‘Nanguo’ and ‘Nanhong’ pear fruit development. Both the fructose contents of the ‘Nanguo’ and ‘Nanhong’ pears reached the highest point at day 8.21, which were 62.87 and 76.85 $\text{mg} \cdot \text{g}^{-1}$, respectively. But what is different is that the fructose content of the ‘Nanguo’ pear remained basically unchanged after day 8.21, but the ‘Nanhong’ pear then declined after day 8.21 and then increased at the harvest day. The glucose change trend of the ‘Nanhong’ pear is basically the same as the ‘Nanguo’ pear, reaching the highest point at day 7.22, which were 22.21 and 21.18 $\text{mg} \cdot \text{g}^{-1}$, respectively and then started to decrease a little. What is different is that before day 8.6, the glucose content of the ‘Nanhong’ pear is higher than the ‘Nanguo’ pear, but after that date, the glucose content is higher in the ‘Nanguo’ pear. The sorbitol change trend of the ‘Nanhong’ pear is also basically the same as the ‘Nanguo’ pear: with fruit development, the sorbitol content increased gradually and reached its highest point at day 7.22, 43.65 and 45.18 $\text{mg} \cdot \text{g}^{-1}$, respectively, then started to decrease a little. But the ‘Nanhong’ pear showed an increase at day 9.14. During the early stage of fruit development, there existed no obvious differences between the sucrose contents of the ‘Nanguo’ and ‘Nanhong’ pears. But at the harvest day, the sucrose content of the ‘Nanhong’ pear is dramatically higher than the ‘Nanguo’ pear, almost double when compared to the ‘Nanguo’ pear, which were 29.82 and 16.06 $\text{mg} \cdot \text{g}^{-1}$, respectively. This is the first time that anyone has compared the differences between soluble sugars of the ‘Nanguo’ pear and its bud mutation, the ‘Nanhong’ pear. From our results, we found that the sucrose content of the ‘Nanhong’ pear is higher than that of the ‘Nanguo’ pear, especially at the harvest day. In order to understand why the sucrose content is different between these two pears, we analyzed the expression profile of several sucrose related genes. We performed a blast search by using the NCBI database and pear genome, finally we obtained one NI (Neutral Invertase), two SPS (Sucrose-phosphate Synthase) and three SS (Sucrose Synthase). Based on these gene sequences, we designed specific primers and analyzed their expression profiles during the ‘Nanguo’ and ‘Nanhong’ pear’s fruit development. The *PuNI* showed a higher expression level in the ‘Nanguo’ pear than in the ‘Nanhong’ pear, especially at days 6.22 and 8.21, showing a double to fourfold change. At the early development stage, the expression level of *PuSPS1* was higher in the ‘Nanguo’ pear than in the ‘Nanhong’ pear, but at the other development stage, the *PuSPS1* showed a higher expression level in the ‘Nanhong’ pear. The expression of *PuSPS2* showed no expression regularity, sometimes higher in the ‘Nanguo’ pear, while sometimes higher in the ‘Nanhong’ pear. SS is one type of glycosyltransferase and it can catalyze the sucrose synthesis and decomposition, primarily catalyzing decomposition. *PuSS1* and *PuSS2* showed higher expression levels in the ‘Nanhong’ pear, while *PuSS3* was expressed higher in the ‘Nanguo’ pear.【Conclusion】The expression differences of these three types of key genes may explain why the ‘Nanhong’ pear has a higher content of sucrose than the ‘Nanguo’ pear.

Key words: ‘Nanguo’ pear; ‘Nanhong’ pear; Sucrose; Neutral invertase; Sucrose synthase; Sucrose-phosphate synthase

‘南果梨’是辽宁省的一个极具地方特色的秋子梨(*Pyrus ussuriensis* Maxim)品种,其果实色泽鲜艳,

果肉细腻多汁、芳香味浓,深受消费者的喜爱。其芽变品种‘南红梨’^[1]因成熟后果皮黄里透红,市场销售