果 树 学 报 2017,34(6):735-743
Journal of Fruit Science

DOI:10.13925/j.cnki.gsxb.20160389

石榴采后果皮褐变影响因子的研究

齐笑笑[1,3],秦改花[2,3]*

([1]安徽广播电视大学农业与医疗卫生学院,合肥 230022;[2]安徽省农业科学院园艺研究所,合肥 230031;
[3]园艺作物种质创制与生理生态安徽省重点实验室,合肥 230031)

摘 要:【**目的**】针对白皮石榴采后果皮褐变严重的问题,明确其采后果皮褐变的机制。【**方法**】以'白花玉石籽'为材料,研究贮藏期间果皮褐变指数及相关生理生化指标的变化。【**结果**】贮藏过程中,果皮失重率及褐变指数随着贮藏时间的延长而逐渐增加。非酶促褐变指标还原糖和氨基酸态氮与褐变程度有显著相关性。还原糖呈先下降后小幅上升趋势;氨基酸态氮含量呈逐步降低的趋势;而5-HMF含量总体呈上升趋势。酶促褐变指标酚类底物、多酚氧化酶(PPO)活性变化与褐变指数呈极显著相关。PPO活性持续下降;总酚含量先下降,然后随着褐变的发生而上升。果皮褐变过程也伴随着细胞渗透物的外渗和组织的衰老。与褐变指数的相关性分析表明,果皮褐变指数分别与失重率及还原糖、总酚、MDA含量呈显著正相关,与氨基酸态氮、PPO活性则呈极显著负相关。【**结论**】采后石榴果皮褐变既有酶促褐变也有非酶促褐变。

关键词:石榴;果皮;褐变;采后生理生化

中图分类号:S665.4　　**文献标志码**:A　　**文章编号**:1009-9980(2017)06-0735-09

Study on the factors influencing postharvest browning of the pomegranate peel

QI Xiaoxiao[1,3], QIN Gaihua[2,3]*

([1]College of Agriculture, Medicine and Health, Anhui Radio and Television University, Hefei 230022, Anhui, China; [2]Horticultural Research Institute, Anhui Academy of Agricultural Sciences, Hefei 230031, Anhui, China; [3]Key Laboratory of Genetic Improvement and Ecophysiology of Horticultural Crop, Hefei 230031, Anhui, China)

Abstracts:【Objective】Pomegranate (*Punica granatum* L.) is popular among consumers because of its delicious flavor, high nutritional value and medicinal benefits. However, the fruits senesce rapidly after harvest with rapid peel browning, resulting in the reduction of commercial value. The white peel pomegranate cultivar 'Baihuayushizi' was used as test material to understand the mechanism of peel browning during storage.【Methods】Pomegranate fruits were harvested from a commercial orchard in Huaiyuan county, Anhui province. The fruits were precooled immediately at 4 ℃ after harvest and then were transported in the foam-boxes with ice to the Key Laboratory of Genetic Improvement and Ecophysiology of Horticultural Crop (Hefei) by car. Normal fruits were selected and stored at room temeperatre (25±2 ℃). The fruits were stored for 6 days and were sampled once each day from the beginning of the storage. The peel was cut off and then stored in the liquid nitrogen for experiment. The physiological and biochemical parameters were assayed at one-day interval. There were 3 replications for each assay and 10 fruits for each replication. The physiological and biochemistry indicators including browning index, water loss rate, reducing sugar, amino acid nitrogen, 5-hydroxymethylfurfural (5-HMF), total polyphenols, polyphenol oxidase

收稿日期:2016-11-18　　接受日期:2017-02-01

基金项目:安徽省高校自然科学研究项目(KJ2015A443);安徽省果树产业技术体系(AHCYTX-10)

作者简介:齐笑笑,女,讲师,博士,主要从事果实品质生理研究。Tel: 0551-63731305,E-mail: qxxaou@163.com

*通信作者 Author for correspondence. Tel: 0551-62160858,E-mail: qghahstu@163.com

(PPO), malonaldehyde (MDA) and 1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging ability were measured.【Results】Water loss rate in the peel of pomegranate gradually increased with prolonging of the storage. The highest water loss rate (20.90%) was found on the 6th day of the stroage. Browning index was significantly and gradually increased with progress of the storage ($P<0.05$). The browning index on the 6th day of the storage was 0.661. There were significant correlations between the related indicators of non-enzymatic browning such as reducing sugar content, amino acid nitrogen and browning degree. During the storage, the content of reducing sugar decreased at first and then slightly increased. The content of reducing sugar on the 6th day was 1.34 fold higher than that on the 3rd day of the storage. The content of amino acidic nitrogen in the peel gradually decreased and the content of 5-HMF increased with fluctuation during the storage. The phenolic substrate and PPO activity were significantly correlated with browning index of the peel. Decreasing trend was observed in the activity of PPO from the first day to the 6th day during the storage. The maximum PPO activity was recorded on the first day (550 $U \cdot g^{-1} \cdot min^{-1}$), and then remarkably decreased. The content of total polyphenols decreased at first and then increased as browning. The results indicated that postharvest browning of the pomegranate peel was associated with enzymatic browning and non-enzymatic browning. The MDA content increased gradually during the storage. The 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging activity in pomegranate fruit peel increased at the beginning of storage but decreased sharply during the later stage of the storage. The DPPH free radical scavenging activity of the pomegranate peel ranged from 71.35% to 77.72%. And the highest DPPH free radical scavenging activity was found on the 3rd day of the storage. Correlation analysis showed that there was a significant positive relationship between the browning index and the water loss rate ($r=0.896^{**}$), the reducing sugar content ($r=0.465^{*}$), the total polyphenols ($r=0.808^{**}$) and the MDA content ($r=0.950^{**}$), and a significantly negative correlation between the amino acid nitrogen ($r=-0.860^{**}$) and the PPO activity ($r=-0.926^{**}$).【Conclusion】This study investigated the browning of the postharvest pomegranate peel during the storage at room temperature. The obvious water loss was observed and the higher MDA content might indicate that lower membrane integrity in the storage period might be the causes for browning of the pomegranate peel during the storage. The postharvest browning of the pomegranate peel could attribute to the enzymatic browning and the non-enzymatic browning. This progress was associated with enzymatic oxidation of phenolics by PPO. The 5-HMF could lead to non-enzymatic browning.

Key words: Pomegranate; Peel; Browning; Postharvest physiology and biochemistry

石榴(*Punica granatum*)为石榴科(Punicaceae)石榴属(*Punica* L.)多年生落叶果树,原产于中亚地区,目前在整个热带、亚热带和温暖地带等地均有栽培[1-2]。石榴是一种集食用、药用和观赏价值为一体的珍贵水果,具有广泛的开发利用价值[3-4]。石榴属于非跃变型果实,采后贮藏期间极易发生果皮衰老褐变,使感官及营养品质迅速劣变,严重降低了果实的商品价值,石榴果皮褐变已成为制约产业发展的重要问题之一[5-6]。因此,开展石榴果实采后果皮褐变机制研究对石榴产业发展、提升石榴产业经济效益意义重大。前人研究发现,果实贮藏过程中有酶促褐变和非酶促褐变。酶促褐变主要是酚类物质在多酚氧化酶(PPO)的催化下氧化形成褐色物质[7]。非酶促褐变主要有还原糖和游离氨基酸生成的美拉德褐变、焦糖化反应、多酚氧化聚合反应,其中美拉德反应是果蔬采后贮藏过程中最常见的非酶促褐变[8]。采后果实果皮褐变可能与果皮失水[9-10]、酶活性[11-12]、花色素苷[13-14]、总酚含量的变化[15-16]及细胞膜结构的完整性有关[17-18]。

针对石榴果皮的褐变机制前人已有一些报道,有研究认为石榴果皮组织因自由水散失、干燥失水引起了果皮褐变[19-20];Elyatem等[21]研究认为石榴果皮褐变是低温冷害的结果;Kahn[22]研究认为创伤褐变由儿茶酚酶促氧化产生,在有氧条件下多酚氧化