International Journal of Biological Macromolecules 251 (2023) 126303

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

Effects of salicylic acid-grafted bamboo hemicellulose on gray mold control in blueberry fruit: The phenylpropanoid pathway and peel microbial community composition

Rongyu Du [a,c], Jia Deng [a,c,*], Erbin Huang [a,c], Lin Chen [b,c], Junrong Tang [b,c], Yun Liu [a], Zhengjun Shi [a], Fang Wang [b,c,*]

[a] *Key Laboratory for Forest Resources Conservation and Use in the Southwest Mountains of China, Ministry of Education, Southwest Forestry University, Kunming 650224, PR China*

[b] *Key Laboratory of State Forestry Administration on Biodiversity Conservation in Southwest China, Southwest Forestry University, Kunming 650224, PR China*

[c] *Forestry college, Southwest Forestry University, Kunming 650224, PR China*

A R T I C L E I N F O

Keywords:
Bamboo hemicellulose
Salicylic acid
Graft copolymer
Blueberry fruit
Induced disease resistance
Microbial communities

A B S T R A C T

Bamboo hemicellulose (HC) is a natural plant polysaccharide with good biocompatibility and biodegradability. But its poor antibacterial activity limits its application in fruits preservation. In this study, based on the good inducer of salicylic acid (SA) for plant diseases resistance, a novel antibacterial coating material was synthesized by grafting SA onto HC. The study aimed to investigate the synergistic effect of HC-g-SA on antibacterial ability, induces diseases resistance and microbial community composition of postharvest fruit. The graft copolymer treatment significantly reduced the incidence of gray mold caused by *Botrytis cinerea* in blueberries during storage ($P < 0.05$), and significantly stimulated the activity of key enzymes, including phenylalanine ammonia-lyase, chalcone isomerase, laccase, and polyphenol oxidase, leading to an increase in fungicidal compounds such as flavonoids, lignin, and total phenolics produced by the phenylpropanoid pathway in blueberries ($P < 0.05$). Moreover, the HC-g-SA coating altered bacterial and fungal community composition such that the abundance of postharvest fruit-peel pathogens was significantly reduced. After 8 days storage, the blueberry fruits treated by HC-g-SA had a weight loss rate of 12.42 ± 0.85 %. Therefore, the HC-g-SA graft copolymer had a positive impact on the control of gray mold in blueberry fruit during postharvest storage.

1. Introduction

Commonly known as lingonberry, blueberry (*Vaccinium* spp.), of the Rhododendron family, is often referred to as “King of Fruits” because of its high contents in various amino acids, trace elements, anthocyanins, flavonoids, ursolic acid, and other health-related substances with strong antioxidant properties, for which it is renowned as highly beneficial for liver protection, life extension, anticancer prevention, and heart protection [1]. However, rapid water loss and microbial infections mainly fungal outbreaks makes the preservation of blueberries in storage extremely difficult, since they are harvested [2]. Particularly, the search for safe, environmentally friendly, and inexpensive materials for effective control of gray mold caused by *Botrytis cinerea* in blueberries is paramount for the preservation of fruit quality and market value.

Current blueberry preservation practice includes physical measures, such as low temperature [1], ultrasound [3], and ozone [4]. Alternative, chemical measures include fumigation, calcium treatment, and edible coatings. Although these measures can extend storage duration and preserve the quality of blueberries to varying extents, their effectiveness is rather limited [5]. On the other hand, inducing blueberry fruit resistance to pathogens is an effective way to delay fruit decay. Further, salicylic acid (SA), reportedly acts as a trigger signaling molecule to induce the biosynthesis of defense substances, including pathogenesis-related (PR) proteins and polyphenols [6]. Indeed, various compounds produced via the phenylpropanoid pathway play an important role in horticultural fruit-defense mechanisms due to their toxic effects and physical barriers functions. Numerous recent studies have shown the positive effects of SA and its derivatives on the induction of biosynthesis of defense compounds including pathogenesis-related (PR) proteins (chitinase and β-1,3-glucanase) or polyphenol compounds. The results of

* Corresponding authors at: Forestry college, Southwest Forestry University, Kunming 650224, PR China.
E-mail addresses: dengjia1983@163.com (J. Deng), 35445230@qq.com (F. Wang).

https://doi.org/10.1016/j.ijbiomac.2023.126303
Received 15 June 2023; Received in revised form 1 August 2023; Accepted 10 August 2023
Available online 16 August 2023
0141-8130/

羧甲基壳聚糖诱导罗伦隐球酵母对葡萄柚果实细胞壁代谢的影响

杜嵘宇[1]，黄二宾[1]，吴化雨[1]，王 芳[1,2]，邓 佳[1,3,*]

（1.西南林业大学林学院，云南 昆明 650224；2.西南地区生物多样性保育国家林业局重点实验室，云南 昆明 650224；3.西南山地森林资源保育与利用教育部重点实验室，云南 昆明 650224）

摘 要：以‘里约红’葡萄柚为试材，对羧甲基壳聚糖（carboxymethyl chitosan，CMCS）、罗伦隐球酵母（*Cryptococcus laurentii*）以及CMCS-*C. laurentii*处理葡萄柚果实采后的硬度进行测定，结果显示：与对照组（无菌水处理）相比，CMCS-*C. laurentii*处理显著抑制了葡萄柚果实在整个贮藏期间内的果实硬度下降（P<0.05）。在此基础上，测定贮藏期间（75 d）葡萄柚果实质量损失率、细胞壁多糖物质含量和细胞壁水解酶活力并观察果实细胞壁微观结构。结果表明：CMCS-*C. laurentii*处理能有效维持果实内共价结合型果胶、紧密型半纤维素的含量，降低果实中水溶性果胶、离子型果胶以及松散型半纤维素的含量；并且相较于对照组，CMCS-*C. laurentii*处理组果实细胞壁水解酶（果胶甲酯酶、多聚半乳糖醛酸酶、纤维素酶、*α*-*L*-阿拉伯呋喃糖苷酶和*β*-葡萄糖苷酶）活性均受显著抑制；贮藏中后期，CMCS-*C. laurentii*处理的果实细胞壁结构更加稳定，胞内结构相对完整。综上所述，CMCS-*C. laurentii*处理能减缓采后葡萄柚果实细胞内部细胞器及细胞壁的降解，较好地维持细胞完整性，延缓果实软化。

关键词：果实软化；葡萄柚；羧甲基壳聚糖；罗伦隐球酵母；细胞壁代谢

Effect of Carboxymethyl Chitosan on Cell Wall Metabolism of Grapefruits Induced by *Cryptococcus laurentii*

DU Rongyu[1], HUANG Erbin[1], WU Huayu[1], WANG Fang[1,2], DENG Jia[1,3,*]

(1. College of Forestry, Southwest Forestry University, Kunming 650224, China;
2. Key Laboratory of Biodiversity Conservation in Southwest China, State Forest Administration, Kunming 650224, China;
3. Key Laboratory of Forest Resources Conservation and Utilization in the Southwest Mountains of China Ministry of Education, Kunming 650224, China)

Abstract: The hardness of ‘Rio Red’ grapefruits treated postharvest with carboxymethyl chitosan (CMCS), *Cryptococcus laurentii* or *C. laurentii* induced by CMCS was measured during storage. The results showed that compared with the control group (treatment with sterile water), CMCS-*C. laurentii* treatment significantly maintained the firmness of grapefruits during storage (P < 0.05). Moreover, fruit mass loss percentage and the polysaccharide content and polysaccharide hydrolase activity of the cell wall were measured and cell wall microstructure was observed during storage for 75 days. The results indicated that CMCS-*C. laurentii* treatment was effective in maintaining the contents of sodium carbonate soluble pectin (SCSP) and 24% KOH-soluble fraction (24KSF) and reducing the contents of water-soluble pectin (WSP), ionic-soluble pectin (ISP) and 4% KOH-soluble fraction (4KSF) in the fruit. Compared with the control group, the activities of the cell wall-degrading enzymes pectin methylesterase (PE), polygalacturonase (PG), cellulase (CX), *α*-*L*-arabinofuranosidase (*α*-*L*-Af) and *β*-galactosidase (*β*-Gal) were significantly inhibited by CMCS-*C. laurentii* treatment. In the middle and later stages of storage, the cell wall structure of the fruit treated with CMCS-*C. laurentii* was more stable and the intracellular structure was relatively intact. In conclusion, CMCS-*C. laurentii* treatment can slow down the degradation of organelles and cell walls in postharvest grapefruits, maintain cell integrity better and delay fruit softening.

Keywords: fruit softening; grapefruits; carboxymethyl chitosan; *Cryptococcus laurentii*; cell wall metabolism

DOI:10.7506/spkx1002-6630-20230220-185

中图分类号：TS255.36 文献标志码：A 文章编号：1002-6630（2024）05-0243-07

收稿日期：2023-02-20

基金项目：国家自然科学基金地区科学基金项目（31960326；32160394）；云南省农业联合专项（202101BD070001-065）；云南省“高层次人才培养支持计划”项目（YNWR-QNBJ-2020-205）；云南省“两类”人才培养项目（202105AC160045）

第一作者简介：杜嵘宇（1998—）（ORCID: 0000-0002-7683-0559），男，硕士研究生，研究方向为经济林栽培与利用。E-mail: d13663918224@163.com

*通信作者简介：邓佳（1983—）（ORCID: 0000-0002-2361-0341），女，教授，博士，研究方向为果树栽培与利用。E-mail: dengjia1983@163.com