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Procedia Engineering 37 (2012) 150 – 154

Procedia Engineering

www.elsevier.com/locate/procedia

The Second SREE Conference on Engineering Modelling and Simulation (CEMS 2012)

Effect of nitric oxide treatment on storage quality of Glorious oranges

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Abstract

Effect of nitric oxide (NO) treatment on storage quality and disease resistance of Glorious oranges was investigated in the experiment. The results showed that NO treatment could effectively reduce disease incidence inoculated with *Collletotichum goeosporioides* Penz and inhibit the increase of lesion diameter of Glorious oranges during storage. Compared with the control, NO treatment kept higher level of titritable acidity (TA), soluble protein, ascorbic acid (ASA) and reducing sugar, and lower level of weight lose rate and soluble solid concentration (SSC), retarding ripening of fruits.

Keywords: Nitric oxide; Glorious oranges; disease resistance; storage quality

1. Introduction

Nitric oxide (NO), which is a highly reactive free radical gas, is established as a multifunctional signaling molecule in physiological processes of plants [1-2]. It was reported in previous researches that NO could delay the senescence of the fruits by decreasing the sensitivity of ethylene and inhibiting ethylene biosynthesis [3-4]. Leshem found that the senescence of pea treated by suitable NO could be delayed [5]. By now, many researches had demonstrate that exogenous application of NO, which had been widely used in strawberry, peach, cucumber, kiwifruit, could delay the onset of ripening and senescence , extend the shelflife of fruits [6-9]. Glorious oranges is one of the most important fruits in slack season and one kind of the largest sweet orange variety in china. However, the senescence and pathological

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doi:10.1016/j.proeng.2012.04.218

breakdown limit the long-term storage capability of Glorious oranges. Our objective was to explore the effect of exogenous application of NO donors sodium nitroprusside (SNP) on storage quality of Glorious oranges, supporting a basis for NO on fruit refreshing application.

2. Materials and methods

2.1. Plant materials

Fruits of Glorious oranges (*Citrus Sinensis Osbeck*) at the commercially mature stage were harvested from an orchard in Chongqing. Fruit were selected for uniformity, shape, colour, and size, and not any blemished or diseased fruit discards. Fruits were dipped in 30, 50 and 100μmol/L SNP for 10 min. Control fruits were dipped in distilled water for 10 min. Then, all fruits were individually packaged with plastic bags and stored at 20℃ and 85-95% RH.

2.2. Determination of disease incidence and lesion diameter inoculated with spores of Collletotichum goeosporioides *Penz. (1×10^5 conida per milliliter)*

Fruit were sterilized with 70% ethanol and injured with a syringe at 2 points (3 mm deep ×4 mm wide) at the equator of each fruit. 15μL the conidial suspension (1×10^5 CFU mL^{-1} *Collletotichum goeosporioides* Penz.) was injected into each wounded site after 4 h. The fruit were individually packaged with plastic bags 8 h after inoculation, then constantly incubated at 20℃, 85-90% RH. Disease incidence of the fruit and lesion diameter on the each fruit were recorded daily. When the wide of visible rot zone outside the wounded area on fruit was more than 1mm, it was counted as decayed fruit. Disease incidence was measured according to the method of Zeng et al[10].

2.3. Determination of weight loss rate, soluble solid concentration (SSC), titritable acidity (TA), soluble protein, ascorbic acid (ASA) and reducing sugar content

Weight loss rate was expressed as percentage of weight loss relative to the initial value. SSC was determined with a refractometer, and TA by titration with 0.1 N NaOH to pH 8.1 and TA results are given as percentage of citric acid [11]. Soluble protein content was measured and modified according to Bradford (1976), expressed as mg/g FW [12]. Ascorbic acid content was measured according to El-Bulk *et al* (1997) [13], and was expressed as mg/100g FW. Reducing sugar content was expressed as 100 %.

2.4. Statistical analysis and experiment replicates

All Statistical analyses were performed using SPSS 11.0 software. Mean separations were performed by employing Duncan's multiple comparison procedure. Each experiment had three replicates.

3. Results

3.1. Effect of NO on disease incidence and lesion diameter inoculated with spores of Collletotichum goeosporioides Penz. in Glorious oranges

The disease incidence in Glorious Oranges treated with 50μmol/L SNP was lower than control fruits during storage (Fig.1 A). Meanwhile, lesion diameter in SNP-treated fruits was lower than that of the control, especially 50μmol/L SNP treatment (Fig.1 B).

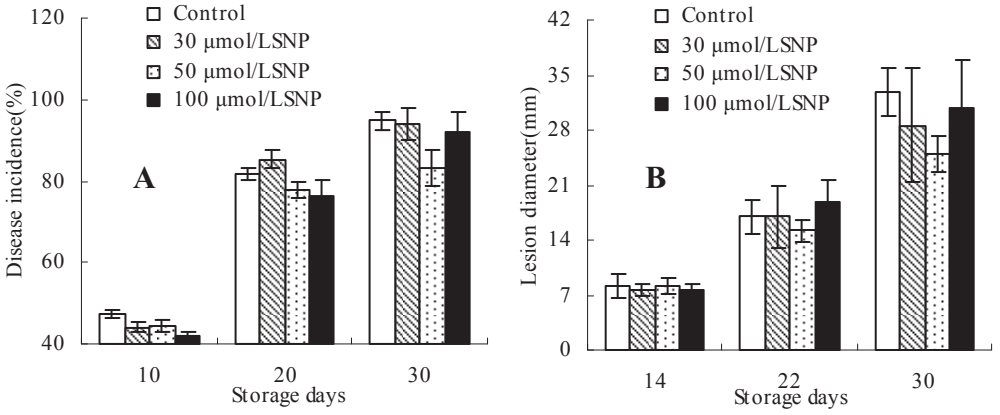

Fig. 1 Effect of NO on disease incidence and lesion diameter inoculated with spores of *Collletotichum goeosporioides* Penz. in Glorious oranges

3.2. Effect of NO on weight loss rate, soluble protein, SSC and TA content in Glorious oranges

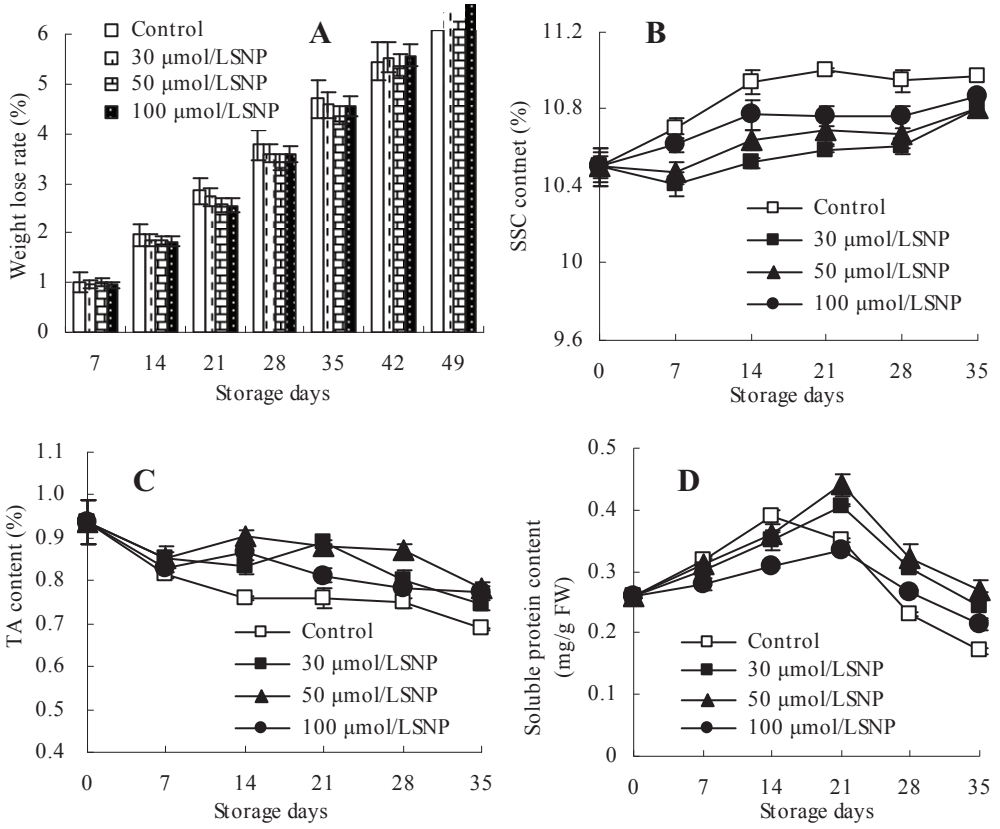

Fig. 2 Effect of NO treatment on weight loss rate, SSC, TA and soluble protein content in Glorious oranges

In Fig. 2 (A), weight loss rate was persistently increased during storage. Glorious oranges treated with 50μmol/L SNP had the lowest weight loss rate among other treatments during storage. However, there was no significant difference among SNP treatments and control. As was showed in Fig. 2 (B), increase tendency of SSC was inhibited by SNP treatment during fruits storage. SSC in Glorious oranges treated by 30, 50 and 100μmol/L SNP was about 3.23, 2.82 and 2.19% lower than that in control by 21th day, respectively. In Fig. 2(C), TA content in Glorious oranges decreased gradually during storage, but SNP treatments had significant effects compared to control TA content decreasing. By 28th day, TA content in 30, 50 and 100μmol/L SNP treated Glorious oranges was about 7.36, 17.64 and 4.95% higher than that in control, respectively. In Fig. 2(D), soluble protein content was increased gradually, followed by a decrease after 21 days. Compared with control, SNP treatments kept higher level of soluble protein content during later storage period, especially 30 and 50μmol/L SNP treatments. By 28th day, soluble protein content in 30 and 50μmol/L SNP treated Glorious oranges was about 32.46 and 39.40 % higher than that in control sample, respectively.

3.3. Effect of NO on ASA and reducing sugar content in Glorious oranges

In Fig. 3(A), ASA content in control and SNP-treated Glorious oranges increased at the early storage, followed by a decline in the 14th d of storage. ASA content in 30, 50 and 100μmol/L SNP treated fruit was higher than that in control. In Fig. 3(B), SNP treatments had effect on increasing reducing sugar content during storage. Fruit treated with 50μmol/L SNP had the highest ASA and reducing sugar content than other treatments.

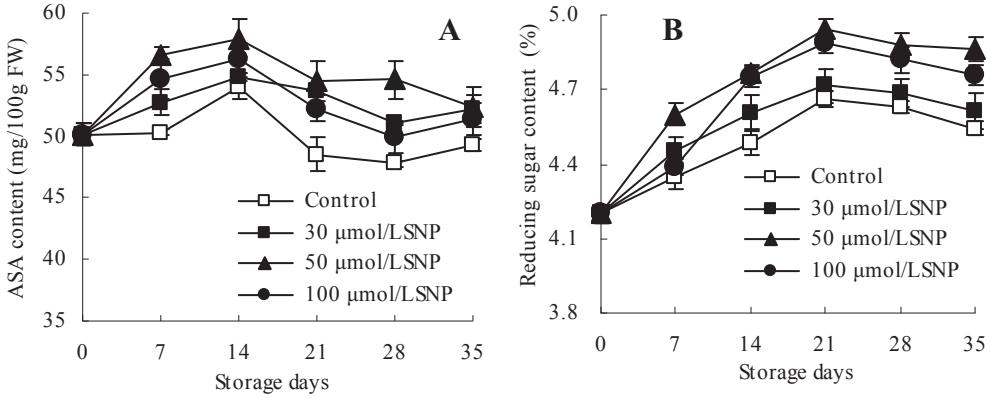

Fig. 3 Effect of NO treatment on ASA and reducing sugar content in Glorious oranges

4. Discussion

NO has antioxidant properties and also been reported to play an important role in the ROS metabolism and signal network during normal and stress conditions [1]. Leshem and Pinchasov reported that NO may be a natural senescence-delaying substance that acts primarily by down-regulating ethylene emission [3]. During storage, fruit is easy to lose water, which makes freshness and commodity value down. It was reported that NO fumigation had effect on reducing water loss during mango fruit ripening [8]. Our study showed that NO treatment could decrease weight loss rate in Glorious oranges during storage, especially 50μmol/L SNP treatment (Fig. 2(A)). The study was agreed with Zhu *et al*, who found strawberry treated with 5μmol/L SNP had better quality than other SNP treatments [14]. We also found that the incidence and development of disease symptoms in Glorious oranges were reduced by the NO treatment (Fig. 1).

The contents of soluble protein, TA, SSC, ASA and reducing sugar were the factors which may be affected by the ripening of fruits. Our study showed that NO treatment could increase soluble protein, TA,

ASA and reducing sugar content in Glorious oranges during storage. Liu *et al*. reported that NO maintained good storage quality on the soluble sugar, soluble solid content, firmness and starch [15]. It was also reported that NO had effect on delaying ASA content decreasing on longan, strawberry and kiwi fruit [9, 14], which was similar to our results.

In conclusion, NO treatment could enhance disease resistance in Glorious oranges and keep higher levels of titritable acidity (TA), soluble protein, ascorbic acid (ASA) and reducing sugar, and lower levels of weight lose rate and soluble solid concentration (SSC), retarding ripening of fruit. Therefore, NO treatment could be used in fruits refresh storage.

Acknowledgements

This work was supported by the National Natural Science Foundation of China (Grant No. 31071618), the Fundamental Research Funds for the Central Universities (XDJK2010B001) and Special Fund for Agro-scientific Research in the Public Interest (201203034). *Corresponding author.

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