Application of nitric oxide to extend the shelf life of mango fruit

Article *in* Acta Horticulturae · June 2015

DOI: 10.17660/ActaHortic.2015.1088.11

CITATIONS
2

READS
742

6 authors, including:

T.T.L. Tran
Vinh Long Community College
2 PUBLICATIONS **5** CITATIONS
SEE PROFILE

Varit Srilaong
King Mongkut's University of Technology Thonburi
176 PUBLICATIONS **1,244** CITATIONS
SEE PROFILE

Pongphen Jitareerat
King Mongkut's University of Technology Thonburi
130 PUBLICATIONS **784** CITATIONS
SEE PROFILE

Chalermchai Wongs-Aree
King Mongkut's University of Technology Thonburi
189 PUBLICATIONS **1,039** CITATIONS
SEE PROFILE

Application of Nitric Oxide to Extend the Shelf Life of Mango Fruit

T.T.L. Tran, S. Aiamla-or, V. Srilaong, P. Jitareerat, C. Wongs-Aree and A. Uthairatanakij[a]
Division of Postharvest Technology, School of Bioresources and Technology
King Mongkut's University of Technology Thonburi
Bangkhuntein Rd., Thakham, Bangkhuntein
Bangkok 10150
Thailand

Keywords: *Mangifera indica* L., sodium nitroprusside, physiology, fruit quality

Abstract

Nitric oxide (NO), a highly reactive free radical gas, has been used as a postharvest treatment to delay fruit ripening and senescence. NO inhibits ethylene production and extends the shelf life of various fruit. The objective of this research was to determine the effect of sodium nitroprusside (SNP), a NO donor, on the quality of mango fruit during storage. Uniform and unblemished mango fruit cv. Nam Dok Mai Si Thong were soaked in 0.5 or 1 mM of SNP for 10 min; dipping in water for 10 min served as the control. After treatment, all fruit were stored at ambient temperature (22°C). Both SNP concentrations significantly reduced ethylene production and respiration rate. Only 1 mM SNP maintained firmness and delayed the changes in soluble solid content and titratable acidity. SNP also delayed color development of the pulp, with fruit treated with 1 mM SNP showing the highest L* and hue angle values and lowest a* and b* values. However, SNP had no effect on weight loss compared to the control. The results indicate that SNP treatment at 1 mM for 10 min can be used to maintain quality and extend shelf life of 'Nam Dok Mai Si Thong' mango fruit.

INTRODUCTION

Mango (*Mangifera indica* L.) is an important fruit in the tropics. Postharvest life of fruit is limited by rapid ripening. The changes in internal and external characteristics of fruit such as firmness, color and taste during ripening and storage influence eating quality and commercial value. Treatment with nitric oxide (NO) has been reported to improve postharvest quality of some fruit and vegetables. NO is a bio-active molecule that can regulate ethylene production by direct stoichiometric inhibition or suppression of ethylene biosynthesis enzymes (Manjunatha et al., 2012a). Fumigation with 20 $\mu l \cdot L^{-1}$ of NO for 2 h at 21°C inhibited ethylene biosynthesis, reduced respiration rates, and maintained higher pulp firmness, springiness, cohesiveness, chewiness, adhesiveness, and stiffness of 'Kensington Pride' mango (Zaharah and Singha, 2011a). Treatment of 'Amber Jewel' plums with 10 $\mu l \cdot L^{-1}$ NO gas similarly delayed ripening. NO also alleviated chilling injury in plums during cold storage and effectively inhibited decay (Singh et al., 2009). Sadegh et al. (2012) reported that using SNP at 1 mM could prolong postharvest life of peaches by reducing the rate of ethylene production, delaying softening and increasing the activity of superoxide dismutase and catalase. The objective of this work was to determine the effect of SNP on quality of 'Nam Dok Mai Si Thong' mango fruit.

MATERIALS AND METHODS

'Nam Dok Mai Si Thong' mango fruit at the mature stage were purchased from the Exporting Companyin Bangkok, Thailand. Fruit were washed with tap water and disinfected with 100 ppm Clorox (NaOCl), then air dried for 30 min. Fruit were dipped in 0.5 or 1 mM of SNP solution for 10 min; dipping in water for 10 min served as the

[a] apiradee.uth@kmutt.ac.th

control. After treatment all fruit were stored at ambient temperature (22°C). Ethylene production and respiration rate were measured by taking 1 ml gas samples from the headspace of sealed jar of fruit and measured by gas chromatography (Shimadzu GC-2014 ATF, Japan). The color of fruit peel and pulp was recorded using the colorimeter (Konica Minolta CR-400, Japan). Fruit firmness was measured as compression force using the texture analyzer (TA.XT-plus, UK) (limited distance compression); soluble solid content (SSC) using a hand refractometer (Atago, PAL-1, Japan); and titratable acidity (TA) was determined by titration with 0.1 N NaOH using phenolphthalein as indicator. The Statistical Package for the Social Sciences (SPSS) software for Windows was used for analysis of variance (ANOVA) and least-significant difference (LSD) at the 95% confidence level using a completely randomized design (CRD).

RESULTS AND DISCUSSION

Ethylene Production and Respiration Rate

Ethylene production of mango fruit changed slowly from days 1 to 5, increased sharply to day 6, then decreased. SNP treatments delayed the ethylene peak by one day and the peak values in SNP treated fruit were lower than in untreated fruit. The peak rates of ethylene production were 3.47, 3.24 and 3.05 µl C_2H_4 $kg^{-1} \cdot h^{-1}$ for the control, 0.5 mM and 1 mM SNP treatments, respectively. SNP treatments significantly suppressed the production of ethylene during storage, except on days 7 and 8 (Fig. 1A). Respiration rates increased from days 2 to 6, then decreased. All treatments reached a peak at day 6, the peak value of respiration rate in control fruit was 1.5-fold higher than in the SNP treatments. SNP treatments significantly decreased respiration rates during storage, except on days 1 and 3 (Fig. 1B). The results showed that 1 mM SNP was more effective than 0.5 mM SNP in suppressing respiration and ethylene production compared to the control.

Firmness and Weight Loss

The firmness of mango fruit decreased slightly during storage. Fruit in SNP treatments remained firmer than in the control treatment. Significant differences were found on days 7 and 8, and only treatment with 1 mM SNP maintained significantly higher firmness values in comparison to the control treatment (Fig. 2A). During storage, the weight loss of fruit treated with SNP was lower than untreated fruit (Fig. 2B), but there were no significant differences in weight losses among treatments.

Fruit Color, SSC and TA

At the fully ripe stage (day 8 in control fruit), lower values of a* and b* were detected in the pulp of fruit treated with SNP. SNP also delayed the decrease in hue angle and L* values in the pulp. The 1 mM SNP treatment was more effective than 0.5 mM SNP in reducing the changes in fruit pulp color (Table 1). No significant differences in b* values in the fruit peel were found among treatments. Peel color was not related to a* values. Lower L* and hue angle values were measured in fruit treated with 0.5 mM SNP (Table 2). SSC and TA were measured on day 8 of storage. The results showed that fruit treated with 1 mM SNP had lower SSC and higher TA than the control (Table 3). These changes are associated with an increase in ethylene production and respiration rates; a decrease in flesh firmness; changes in skin and flesh fruit color, an increase in SSC and a decrease in TA (Brecht and Yahia, 2009). Treating mango fruit with 0.5 or 1 mM SNP decreased ethylene production and respiration rates (Figs. 1A and B). NO reduces ethylene production of treated fruit by binding of NO and 1-aminocyclopropane-1-carboxylic acid to form a stable ternary complex (Tierney et al., 2005). NO released by 1 mM SNP aqueous solution effectively retards pericarp reddening of tomato fruit, suppresses ethylene production, and influences quality parameters during storage (Lai, 2011). NO fumigation was reported to reduce respiration in ‘Kensington Pride’ mango fruit during ripening at 21°C (Zaharah and Singh, 2011b). Similarly, NO treatments were found to suppress respiration in plums (Singh et al., 2009), peaches (Flores et al., 2008),

strawberries (Zhu and Zhou, 2007) and tomatoes (Zhang et al., 2005). The maintenance of fruit firmness and fruit weight may be explained by the reduction of water loss and respiration rates. In addition, delaying fruit softening by NO application in this research may be due to the suppression of ethylene production leading to a reduction of softening enzyme activities. NO treatment has been reported to decrease the activity of polygalacturonase, endo-1,4-β-d-glucanase, pectinmethyl esterase and galactosidase in banana fruit during ripening (Cheng et al., 2009; Yang et al., 2010). Sadegh et al. (2012) reported that using SNP at 1 mM could prolong postharvest life of peaches by reducing ethylene production rates and slowing softening. Similarly, pear fruit treated with 20 $\mu l \cdot L^{-1}$ NO had lower rates of ethylene production, reduced activities of polygalacturonase and β-galactosidase, and remainedfirmer leading to delayed softening and ripening in 'Yali' pear fruit (Liu et al., 2011).

The lower a* and b* values and the higher L* and h values in the fruit pulp treated with SNP were probably due to the suppression of ethylene production. Similar results were found in banana fruit fumigated with NO (Cheng et al., 2009). Treatment with 0.5 mM SNP seemed to induce color development in fruit peel by increasing the changes in L* and h values. According to Singh et al. (2009), treating plums with 10 $\mu l \cdot L^{-1}$ NO reduced the changes in fruit skin color, firmness, and TA due to the suppression of respiration and ethylene production. Treatment with SNP at 1 mM delayed the respiratory peak coinciding with a delay in the accumulation of SSC as well as reducing sugars (Manjunatha et al., 2012b). NO treatment in papaya effectively suppressed ethylene formation and respiration, reduced weight loss, maintained firmness and delayed changes in fruit color and SSC during 20 days of storage (Li et al., 2014).

CONCLUSIONS

Postharvest application of SNP effectively maintained the quality of 'Nam Dok Mai Si Thong' mango fruit. Treatment with 1 mM SNP for 10 min suppressed ethylene production and respiration rates, maintained firmness, and slowed the changes in fruit pulp color, SSC and TA. It is proposed that the effects of SNP on the biochemical mechanisms controlling fruit ripening and softening of mango be further investigated.

ACKNOWLEDGEMENTS

This work was supported by the Higher Education Research Promotion and National Research University Project of Thailand, Office of Higher Education Commission and the GMS scholarship, KMUTT, Thailand.

Literature Cited

Brecht, J.K. and Yahia, E.M. 2009. Postharvest Physiology - The Mango - 2nd Edition: Botany, Production and Uses. CAB International.

Cheng, G., Yang, E., Lu, W., Jia, Y., Jiang, Y. and Duan, X., 2009. Effect of nitric oxide onethylene synthesis and softening of banana fruit slice during ripening. J. Agri. and Food Chem. 57:5799-5804.

Flores, F., Sánchez-Bel, P., Valdenegro, M., Romojaro, F., Martinez-Madrid, M. and Egea, M. 2008. Effects of a pretreatment with nitric oxide on peach (*Prunus persica* L.) storage at room temperature. J. of Europ. Food Res. and Technol. 227:1599-1611.

Lai, T., Wanga, Y., Li, B., Qina, G. and Tiana, S. 2011. Defense responses of tomatofruit to exogenous nitric oxide during postharvest storage. Postharvest Biol. and Technol. 62:127-132.

Li, X., Wu, B., Guo, Q., Wang, J., Zhang, P. and Chen, W. 2014. Effects of Nitric Oxide on Postharvest Quality and Soluble Sugar Content in Papaya Fruit during Ripening. Journal of Food Processing and Preservation 38:591-599.

Liu, L., Dong, Y. and Guan, J. 2011. Effects of nitric oxide on the quality and pectin metabolism of Yali pears during cold storage. J. of Agri. Sciences in China 10(7):1125-1133.

Manjunatha, G., Gupta, K.J., Lokesh, V., Mur, A.L. and Bhagyalakshmi, N. 2012a.

Nitricoxide counters ethylene effects on ripening fruits. Journal of Plant Signaling & Behavior 7(4):476-483.
Manjunatha, G., Lokesh, V. and Bhagyalakshmi, N. 2012b. Nitric oxide-induced enhancement of banana fruit attributes and keeping quality. Acta Hort. 934:799-806.
Sadegh, A.S., Mostofi, Y., Boojar, M.M.A and Khalighi, A. 2012. Effect of nitric oxideon ethylene biosynthesis and antioxidant enzymes on Iranian peach (*Prunus persica* cv. Anjiri). Journal of Food, Agriculture & Environment 10(2):125-129.
Singh, S.P, Singha, Z., and Swinny, E.E. 2009. Postharvest nitric oxide fumigation delaysfruit ripening and alleviates chilling injury during cold storage of Japanese plums (*Prunus salicina* Lindell). Journal of Postharvest Biology and Technology 53:101-108.
Tierney, D.L., Rocklin, A.M., Lipscomb, J.D., Que Jr., L. and Hoffman, B.M. 2005. Studies of the ligation and structure of the non-heme iron site in ACC oxidase. Journal of American Chemistry and Society 127:7005-7013.
Yang, E., Yang, S.Y., Lu, W.J., Chen, J.Y., Qu, H.X., Jiang, Y., Joyce, D.C. and Duan, X.W. 2010.Effect of nitric oxide on the sensitivity of banana fruit slices to ethylene. Journal of Horticulture Science Biotechnology 85:17-22.
Zaharah, S.S. and Singh, Z. 2011a. Postharvest nitric oxide fumigation alleviates chillinginjury, delays fruit ripening and maintains quality in cold stored 'Kensington Pride' mango. Journal of Postharvest Biology and Technology 60:202-210.
Zaharah, S.S and Singh, Z. 2011b. Mode of action of nitric oxide in inhibiting ethylenebiosynthesis and fruit softening during ripening and cool storage of 'Kensington Pride' mango. Journal of Postharvest Biology and Technology 62:258-266.
Zhang, S.Y., Ren, X.L. and Rao, J.P. 2005. Effects of nitric oxide on active oxygen metabolism of postharvest tomato fruit. Acta Horticulturae Sinica 32:818-822.
Zhu, S.H. and Zhou, J. 2007. Effect of nitric oxide on ethylene production in strawberry fruit during storage. Journal of Food Chemistry 100:1517-1522.

Tables

Table 1. Effect of SNP treatment on the pulp color of 'Nam Dok Mai Si Thong' mango fruit at day 8 of storage at 22°C.

Treatments		L* values	a* values	b* values	h values
Day 0		85.36	-1.97	30.68	94.47
Day 8	Control	74.62 ± 0.77b	7.99 ± 0.64a	49.57 ± 0.77a	80.89 ± 0.62c
	0.5 mM SNP	75.68 ± 0.52b	4.78 ± 0.39b	46.70 ± 1.42ab	84.14 ± 0.45b
	1.0 mM SNP	80.64 ± 1.29a	2.12 ± 0.95c	40.33 ± 3.36b	87.44 ± 1.20a

Values represent mean (± S.E.) of measurements (n = 7). Values followed by the different letters within the same column indicate significant differences among treatments at p≤0.05 (LSD test).

Table 2. Effect of SNP treatment on the peel color of 'Nam Dok Mai Si Thong' mango fruit at day 8 of storage at 22°C.

Treatments		L* values	b* values	h values
Day 0		78.84	38.40	94.49
Day 8	Control	74.34 ± 0.60ab	35.72 ± 0.38ns	76.11 ± 0.88a
	0.5 mM SNP	73.27 ± 0.31b	34.57 ± 0.32ns	68.40 ± 0.37c
	1.0 mM SNP	75.72 ± 0.81a	33.97 ± 1.68ns	74.14 ± 0.56b

Values represent mean (± S.E.) of measurements (n=7). Values followed by the different letters within the same column indicate significant differences among treatments at p≤0.05 (LSD test).

Table 3. Effect of SNP treatment on SSC and TA of 'Nam Dok Mai Si Thong' mango fruit at day 8 of storage at 22°C.

Treatments		SSC (°Brix)	TA (% citric acid)
Day 0		12.01	2.32
Day 8	Control	20.31 ± 0.37a	0.50 ± 0.06b
	0.5 mM SNP	20.40 ± 0.18a	0.52 ± 0.04b
	1.0 mM SNP	18.41 ± 0.37b	0.81 ± 0.06a

Values represent mean (± S.E.) of measurements (n=7). Values followed by the different letters within the same column indicate significant differences among treatments at p≤0.05 (LSD test).

Figures

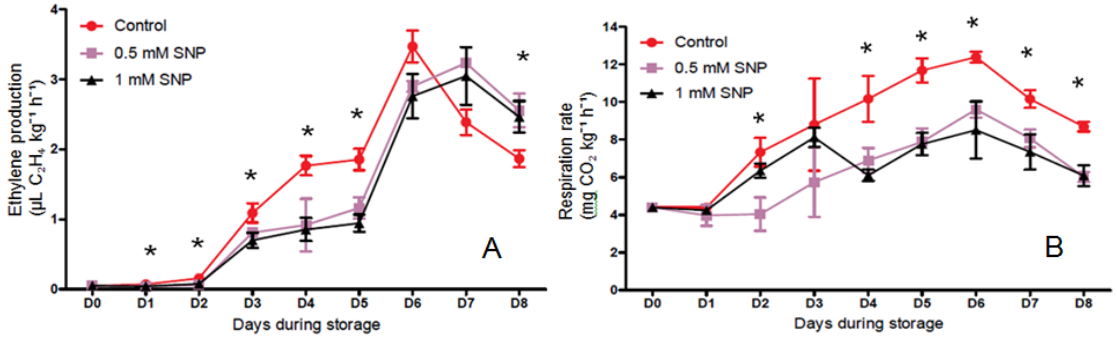

Fig. 1. Effect of SNP treatment on ethylene production (A) and respiration rate (B) in mango fruit. Vertical bars represent S.E of means and are invisible when the values are smaller than the symbols. Asterisks indicate significant differences among treatments at p≤0.05 (LSD test) (n=3).

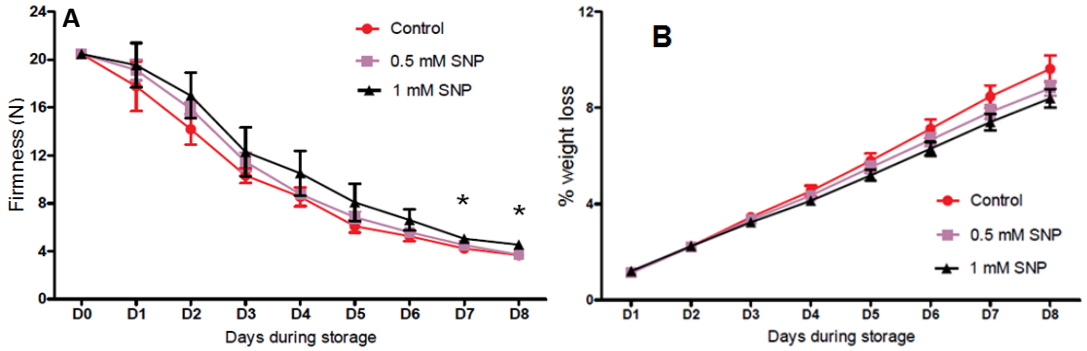

Fig. 2. Effect of SNP treatment on the firmness (A) and weight loss (B) of mango fruit during storage. Vertical bars represent S.E of means and are invisible when the values are smaller than the symbols. Asterisks indicate significant differences among treatments at p≤0.05 (LSD test) (n=3).