Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.6724

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (4):** 671-677 (2018)

Review Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Recent Advances in Woolliness Management in Peach Fruit: A Review

Kuldeep Singh[1*], Nitin P.S.[1], Pradeep Kumar[2], Gururaj Mathapati[2] and Ajay Kumar[3]

[1]Division of Fruits and Horticultural Technology,

[2]Division of Vegetable Science,

[3]Division of Microbiology,

ICAR-IARI, New Delhi 110012, India

*Corresponding Author E-mail: k.chauhan457@gmail.com

Received: 15.07.2018 | Revised: 19.08.2018 | Accepted: 26.08.2018

ABSTRACT

Peaches and nectarines are susceptible to wooliness, a form of chilling injury. It manifests as a lack of juiciness and a dry woolly or leathery texture of the fruit flesh which reduces the shelf life of fruit during cold storage. Wooliness can be alleviated by pre-harvest methods such as application of gibberellins and hexanal formulations, by post-harvest methods such as heat treatment, low temperature conditioning, controlled atmosphere storage (CAS) and application of different chemical melatonin application, 1-methylcyclopropene (1-MCP), oxalic acid, glycine betaine, methyl jasmonate (MeJA), salicylic acid (SA), and nitric oxide. Gibberellin delays the onset of climacteric respiration and ripening cycle. Hexanal application inhibits the enzyme responsible for fruit deterioration and improves fruit firmness. Increase in ethylene production causes chilling injury in fruits, heat treatment and application of 1-MCP inhibit ethylene application. LTC treatment increases the content of ATP and enhances activities of energy metabolism enzymes. The combined treatment of low temperature conditioning (LTC) and MeJA inhibit the activities of PPO and POX while induced the activities of antioxidant enzymes. CAS treatment reduces the activities of endo-PG, exo-PG activities and PME activity; and increasing activities of antioxidant enzymes, and reducing MDA content. Glycine betaine (GB) treatment enhances the accumulation of endogenous GB, γ-aminobutyric acid (GABA), and proline contents. This enhances chilling tolerance in peach fruits and reduces wooliness.

Key words: *Chilling injury, Peach, Pre-harvest treatment and Post-harvest treatment, Wooliness*

INTRODUCTION

Prunus belong to subfamily *Prunoideae*, is the horticulturally important genus in the Rosaceae. *Prunus species* are referred as stone fruit due to the seed is enclosed within a lignified stone-like endocarp. Stone fruits mainly include peach, nectarine (*P. persica* (L.) Batsch), European plum (*P. domestica* L.), Japanese plum (*P. salicina* Lindl.), sour cherry (*P. cerasus* L.), sweet cherry (*P. avium* L.), apricot (*P. armeniaca* L.) and almond (*P. dulcis* Miller).These fruits are cultivated in the temperate regions and have greater demand throughout the world. But these fruits ripen and deteriorate quickly at ambient temperature.

Cite this article: Singh, K., Nitin P.S., Kumar, P., Mathapati, G. and Kumar, A., Recent Advances in Woolliness Management in Peach Fruit: A Review, *Int. J. Pure App. Biosci.* **6(4):** 671-677 (2018). doi: http://dx.doi.org/10.18782/2320-7051.6724

Therefore, cold storage is used to slow these processes and delay development during their transportation and storage but the chilling injury limits the storage life of stone fruits under low temperature.

Woolliness or leatheriness in peaches (mealiness in other fruits) is one form of chilling injury. It manifests as a lack of juiciness and a dry 'woolly' texture of the fruit flesh. This disorder is reported to occur in stone fruits like peaches, plum, nectarines and apricots but majorly affecting peaches and nectarines. Woolliness is not reported in cherry. Although there are some other symptom develop after prolonged cold storage and/or after ripening at room temperature like flesh browning, flesh translucency (gel breakdown), red pigment accumulation (bleeding), black pit cavity, fail to ripen, and lose flavor. While in ripe peaches and nectarines this lack of juiciness was named woolliness[1, 2] and in plums flesh translucency has been called gel breakdown [3]. These symptoms are similar as internal breakdown (IB) or chilling injury (CI)[2, 4, 5]. This brief review comprises the recent research findings related to controlling CI of harvested fruits during cold storage.

Woolliness management

Pre-ripening of fruits before storage:

Ripening of fruits artificially before storage helps in complete degradation of pectin. Thus, the chances of woolliness occurrence are reduced. But it is found that these managements are not much effective as they produce off-flavours and undesirable taste. Thus, there is some recent advanced management for managing woolliness effectively. These advanced managements can be classified into two categories namely pre-harvest and post-harvest.

Pre-harvest methods

These are methods used to manage woolliness before they are harvested

GA application:

GA_3 induces hydrolytic cell wall enzymes, enhancing polysaccharide solubilization and favouring cell expansion. GA_3 is also involved in the protection of endomembrane system, regulating genes involved in its own biosynthetic pathway. GA_3 delays the onset of climacteric respiration and ripening cycle[6]. It also maintains the firmness of the fruits. This treatment (400 L ha^{-1} of a GA_3 solution [50 mg L^{-1} of GA_3 (Proggib®) and surfactant (0.05%, v/v) (Silwet®), pH 4.5]) was recommended for spraying at the beginning of the pit hardening stage (45 days after anthesis, DAA) by Pegoraro *et al*[6].

Hexanal application:

Hexanal, is a naturally occurring compound in plants. Its formulations are effective in enhancing the shelf life of many fruits like mango, peach and sweet cherry[7,8]. Exogenous application of hexanal formulation inhibits the enzyme phospholipase-d, which is involved in fruit deterioration[8,9].

Application of Enhanced Freshness Formulation (EFF) with hexanal (0.02%) delayed the incidence of woolliness by one week[10].The cherry fruits were subjected to pre-harvest spray of hexanal formulation (enhanced freshness formulation, EFF), has resulted in better color, brightness and firmness while post-harvest application of hexanal vapour with combination of 1-MCP, has enhanced the firmness of cherries[11].

Post-harvest Methods

Harvest date and maturity stage:

During storage, late harvested show more woolliness, as compared to the peaches harvested at commercial maturity[12]. Girardi[13] also found that early harvest of peaches can promote other chilling injury symptoms during cold storage.

Heat Treatment

Heat treatment, comprising hot air vapour (HA), hot water dipping (HW) and intermittent warming (IW), are being used on large scale in controlling CI in a number of fruits as it inhibits ethylene synthesis and delays the process of ripening. Jin[14] recommended hot air treatment at 38-39˚C for 12 h as optimum condition for reducing CI in peach. As it inhibits ethylene synthesis, has been reported to delays the softening in plums[15].

However, it can also cause flesh mealiness in peach and nectarine after

harvest[16]. So it is not recommended using heat treatment alone but the combined treatment of HA and methyl jasmonate (MeJA) vapor treatment could reduce chilling injury and maintain the fruit quality during cold storage. Heat treatment combined with salicylic acid (SA) treatment is also an effective method for reducing internal browning in peach fruit during cold storage at 0 °C. This combined treatment induces the activity of antioxidant enzymes system (SOD, CAT, APX and GR), while decrease the activity of lipoxygenase[17].

Long heat treatment (3 or 4 h) can inhibit or drastically decrease polygalacturonase (PG) activity and by this alteration promote chilling injury development. If intermittent warming is used alone it could be useful in alleviating chilling injuries in peaches[13]. Periodical warming of peaches during their storage at low temperatures can maintain the PG activity, which promotes solubilisation of the water-soluble pectin and normal peach ripening. Further it has also been reported that intermittent warming alone is not recommended because these encourage fruit decay and a significant loss of pulp firmness[18].

Low temperature conditioning:

Low-temperature conditioning is an effective method to prevent chilling injury, pathogenic decay and maintaining fruit quality. Fruits are conditioned by exposing them to temperatures little above the critical chilling range before subjecting them to actual storage temperature. This will provide more resistant to subsequent chilling injury[19].

Jin[20] reported the combination of LTC and MJ treatment as a useful technique to reduce CI and maintain quality in peach fruit during cold storage. This combined treatment has significantly inhibited the activities of PPO and POX while induced the activities of antioxidant enzymes (SOD, CAT and APX). LTC treatment also increases the content of ATP and enhances activities of energy metabolism enzymes in peaches[21]

LTC treatment significantly reduced chilling injury and enhanced chilling tolerance of loquat fruit by enhancing endogenous glycine betaine (GB) content and induced activities of energy metabolism-associated enzymes[22]. LTC enhanced the accumulations of proline and MiCBF1 was identified in chilled mango fruit, and its expression was up-regulated by LTC[23].

Controlled atmospheric storage (CAS):

The CAS utilizes the reduction of oxygen (O_2) and increase in carbon dioxide (CO_2) as compared to the ambient atmosphere. Sometimes ethylene and carbon monoxide level are also maintained. By this way it the gas composition affects the storage life of fruits and vegetables[24]. Lowering O_2 and raising CO_2 in the storage atmosphere conferred benefit on the fruit and delayed or prevented the appearance of woolliness[25]. The CO_2 component appears to be critical for delaying the onset of CI [26]. Anderson[26] recommended that 3–5% CO_2 +1–2% O_2 at 0◦C storage technique is considered to be best. While wang[18] recommended this technique (5% O_2 + 5% CO_2) at 0◦C best for the alleviation of CI.

It has been reported that CA treatment reduces the activities of endo-PG, exo-PG activities and PME activity, which is considered to be most suitable treatment for improving the postharvest quality of peaches[13]. Wang [18] found that 70% O_2 atmosphere storage inhibits CI in peach by increasing activities of antioxidant enzymes like SOD and CAT, and reducing the content of MDA.

Melatonin treatment:

Melatonin (N-acetyl-5-methoxytryptamine) is a hormone present in different parts of all of the plant species. It has important role in regulation of stress response, plant growth, and development[27]. Cao[28] reported that treatment with melatonin at 100 μM has induced chilling tolerance in peach after harvest. This treatment has increased polyamines, γ-aminobutyric acid (GABA) and proline content in the treated fruits and induced tolerance against chilling injury.

Application of 1-MCP:

1-Methylcyclopropane (1-MCP) is an ethylene action inhibitor that is used to delay the ripening process and to extend the storage as

well as shelf life of climacteric fruits. Jin [29] reported that the treatment 0.5 or 1 µl L^{-1} of 1-MCP inhibits internal browning and reduces mealiness or woolliness in Asian peaches stored at 0 or 5°C. When the nectarine fruits were treated with 1-MCP at 1µL/L they remained marketable even after 40 days. The activities of PPO, PG and PME have been reduced by 1-MCP treatment and MAP storage[30].

Oxalic acid:

Oxalic acid is an organic acid commonly occurring in plant. OA treatment can effectively enhance chilling tolerance and alleviate CI in various fruits like peach, mango and pomegranate as it increases the antioxidant capacity[31,32,33]. It has significantly increased the contents of ATP, energy charge, enzyme activities of energy metabolism and unsaturated/saturated fatty acid ratio in peach fruit[33].

Glycine betaine (GB):

Glycine betaine is an important osmotic adjustment helps in maintaining cell osmotic pressure, protecting protein or enzymes function, and regulating stress response in plant. It accumulates plant species in response to abiotic stresses such as drought, salinity, extreme temperatures, UV radiation and heavy metals. Exogenous applications of GB to plants even during stress increase the internal levels of GB and generally enhance plant growth and final crop yield under stress conditions[34].

GB treatment could induce chilling-tolerance in peach fruits stored in cold storage. Exogenous GB treatment enhances the accumulation of endogenous GB, GABA and proline contents by inducing their metabolism related enzymes activities[35].

Methyl Jasmonate (MeJA):

MeJA, as a natural plant regulator compound, plays important roles in plant growth and development, fruit ripening, and responses to environmental stress[36]. MeJA treatment alone reduced internal browning and flesh mealiness in peach fruit. The recommended treatment is 1µmol L^{-1} MeJA vapor in a sealed incubator at 20 ◦C for 24 h[14]. It enhances chilling tolerance of peach fruit by inducing enzyme activity related to energy metabolism and maintaining high levels of ATP content and energy charge[37].

Salicylic Acid (SA):

Salicylic acid belongs to a group of plant phenolics. It possesses an aromatic ring bearing a hydroxyl group or its functional derivative. It has important role in regulation of many processes in plant growth and development. It has also role in plant defense mechanism against different biotic and abiotic stresses and is reported to increase chilling tolerance in many fruit crops like kiwi fruit, banana and peach[38,39,40].

The combined treatment of SA with ultrasound has effectively inhibited CI in peach fruit than SA alone. This combined treatment has induced the activities of antioxidant enzymes (CAT, APX, MDAR, DHAR, and GR). In addition, endogenous SA concentrations also increased in peaches[41].

Nitric oxide (NO):

Nitric oxide, a highly reactive free radical gas, acts as a multifunctional signalling molecule in plants tissues[42]. It has role in modulation of plant hormonal and defense against biotic and abiotic stress[43]. Postharvest NO gas (10 µL L^{-1}) treatment has been reported to alleviate chilling injury during cold storage at 0 ℃ for 6 weeks of Japanese plums[44]. NO changes the relationship between PE and PG, which stops the increase in the content of soluble pectin and the reduction in the ionic pectin. The consequence here is reduced woolliness[45].

CONCLUSION

Wooliness can be managed by pre-harvest methods and post-harvest methods. The treatment of methyl jasmonate, salicylic acid and oxalic acid as alone or in combination with other treatment described above reduced the chilling injury and maintained the fruit flesh firmness. These treatments have induced antioxidant enzymes system and maintained the high levels of ATP content and energy charge, helped in reducing wooliness in peaches. Pre-harvest treatment of hexanal formulation and gibberellins maintained flesh

firmness and reduced wooliness incidence. MeJA could enhance chilling tolerance of peach fruit by inducing enzyme activity related to energy metabolism and maintaining high levels of ATP content and energy charg MeJA could enhance chilling tolerance of peach fruit by inducing enzyme activity related to energy metabolism and maintaining high levels of ATP content and energy charge

REFERENCES

1. Von Mollendorff, L. J., Woolliness in peaches and nectarines: A review. 1. Maturity and external factors. *Hort. Sci./Tuinbouwetenskap,* **5:** 1-3 (1987).
2. Von Mollendorff, L. J., Jacobs, G., & De Villiers, O. T. , Cold storage influences internal characteristics of nectarines during ripening. *HortScience,* **27(12):** 1295-1297 (1992).
3. Dodd, M. C., Internal breakdown in plums. *Deciduous Fruit Grower,* **34(8):** 255-6 (1984).
4. Mitchell, F.G. and Kader, A.A., Factors affecting deterioration rate, p. 165–178. *In:* J.H. LaRue and R.S. Johnson (eds.). Peaches, plums and nectarines. Growing and handling for fresh market. Publ. 3331. Univ. of California DANR, Oakland (1989).
5. Smith, W. H., Cold storage of Elberta peaches. *Ice Cold Storage,* **37:** 54-57 (1934).
6. Pegoraro, C., Zanuzo, M. R., Chaves, F. C., Brackmann, A., Girardi, C. L., Lucchetta, L., & Rombaldi, C. V., Physiological and molecular changes associated with prevention of woolliness in peach following pre-harvest application of gibberellic acid. *Postharvest biology and technology,* **57(1):** 19-26 (2010).
7. Anusuya, P., Nagaraj, R., Janavi, G. J., Subramanian, K. S., Paliyath, G., & Subramanian, J., Pre-harvest sprays of hexanal formulation for extending retention and shelf-life of mango (*Mangifera indica* L.) fruits. Scientia horticulturae, **211:** 231-240 (2016).
8. Paliyath, G., & Murr, D. P., *U.S. Patent No. 7,198,811*. Washington, DC: U.S. Patent and Trademark Office (2007).
9. Paliyath, G., Pinhero, R. G., Yada, R. Y., & Murr, D. P., Effect of processing conditions on phospholipase D activity of corn kernel subcellular fractions. *Journal of agricultural and food chemistry,* **47(7):** 2579-2588 (1999).
10. Kumar, S. K., El Kayal, W., Sullivan, J. A., Paliyath, G., & Jayasankar, S., Pre-harvest application of hexanal formulation enhances shelf life and quality of 'Fantasia'nectarines by regulating membrane and cell wall catabolism-associatedgenes. *Scientia Horticulturae,* **229:** 117-124 (2018).
11. Sharma, M., Jacob, J. K., Subramanian, J., & Paliyath, G., Hexanal and 1-MCP treatments for enhancing the shelf life and quality of sweet cherry (Prunus avium L.). *Scientia Horticulturae,* **125(3):** 239-247 (2010).
12. Ju, Z., Duan, Y., & Ju, Z., Leatheriness and mealiness of peaches in relation to fruit maturity and storage temperature. *The Journal of Horticultural Science and Biotechnology,* **75(1):** 86-91 (2000).
13. Girardi, C. L., Corrent, A. R., Lucchetta, L., Zanuzo, M. R., da Costa, T. S., Brackmann, A., ... & Rombaldi, C. V., Effect of ethylene, intermittent warming and controlled atmosphere on postharvest quality and the occurrence of woolliness in peach (*Prunus persica* cv. Chiripá) during cold storage. *Postharvest Biology and Technology,* **38(1):** 25-33 (2005).
14. Jin, P., Zheng, Y., Tang, S., Rui, H., & Wang, C. Y., A combination of hot air and methyl jasmonate vapor treatment alleviates chilling injury of peach fruit. *Postharvest Biology and Technology,* **52(1):** 24-29 (2009).
15. Serrano, M., Martínez-Romero, D., Castillo, S., Guillén, F., & Valero, D., Role of calcium and heat treatments in alleviating physiological changes induced by mechanical damage in plum.

Postharvest Biology and Technology, **34(2):** 155-167 (2004).

16. Fallik, E., Pre storage hot water treatments (immersion, rinsing and brushing). *Postharvest biology and technology*, **32(2):** 125-134 (2004).
17. Cao, S., Hu, Z., Zheng, Y., & Lu, B., Synergistic effect of heat treatment and salicylic acid on alleviating internal browning in cold-stored peach fruit. *Postharvest Biology and Technology*, **58(2):** 93-97 (2010).
18. Wang, Y. S., Tian, S. P., & Xu, Y., Effects of high oxygen concentration on pro-and anti-oxidant enzymes in peach fruits during postharvest periods. *Food chemistry,* **91(1):** 99-104 (2005).
19. Wang, C. Y., Approaches to reduce chilling injury of fruits and vegetables. *Horticultural Reviews*, **15:** 63-95 (1993).
20. Jin, P., Wang, K., Shang, H., Tong, J., & Zheng, Y., Low-temperature conditioning combined with methyl jasmonate treatment reduces chilling injury of peach fruit. *Journal of the Science of Food and Agriculture*, **89(10):** 1690-1696 (2009).
21. Chen, J., Jin, P., Li, H., Cai, Y., Zhao, Y., & Zheng, Y., Effects of low temperature storage on chilling injury and energy status in peach fruit. Transactions of the Chinese Society of Agricultural Engineering, **28(4):** 275-281 (2012).
22. Jin, P., Zhang, Y., Shan, T., Huang, Y., Xu, J., & Zheng, Y., Low-temperature conditioning alleviates chilling injury in loquat fruit and regulates glycine betaine content and energy status. *Journal of agricultural and food chemistry,* **63(14):** 3654-3659 (2015).
23. Zhang, Z., Zhu, Q., Hu, M., Gao, Z., An, F., Li, M., & Jiang, Y., Low-temperature conditioning induces chilling tolerance in stored mango fruit. *Food Chemistry,* **219:** 76-84 (2017).
24. Rama, M. V., & Narasimham, P., Controlled-atmosphere storage| Effects on Fruit and Vegetables (2003).
25. Lurie, S., Controlled atmosphere storage to decrease physiological disorders in nectarines. *International journal of food science & technology,* **27(5),** 507-514 (1992).
26. Anderson, R. E., Parsons, C. S., & Smith, W. L., Controlled atmosphere storage of Eastern-grown peaches and nectarines (1969).
27. Zhang, N., Sun, Q., Zhang, H., Cao, Y., Weeda, S., Ren, S., & Guo, Y. D., Roles of melatonin in abiotic stress resistance in plants. *Journal of Experimental Botany,* **66(3):** 647-656 (2014).
28. Cao, S., Song, C., Shao, J., Bian, K., Chen, W., & Yang, Z., Exogenous melatonin treatment increases chilling tolerance and induces defense response in harvested peach fruit during cold storage. *Journal of agricultural and food chemistry*, **64(25):** 5215-5222 (2016).
29. Jin, P., Shang, H., Chen, J., Zhu, H., Zhao, Y., & Zheng, Y., Effect of 1-Methylcyclopropene on Chilling Injury and Quality of Peach Fruit during Cold Storage. *Journal of food science*, **76(8):** S485-S491 (2011).
30. Özkaya, O., Yildirim, D., Dündar, Ö., & Tükel, S. S., Effects of 1-methylcyclopropene (1-MCP) and modified atmosphere packaging on postharvest storage quality of nectarine fruit. *Scientia horticulturae,* **198:** 454-461 (2016).
31. Ding, Z. S., Tian, S. P., Zheng, X. L., Zhou, Z. W., & Xu, Y., Responses of reactive oxygen metabolism and quality in mango fruit to exogenous oxalic acid or salicylic acid under chilling temperature stress. *Physiologia Plantarum,* **130(1):** 112-121 (2007).
32. Sayyari, M., Valero, D., Babalar, M., Kalantari, S., Zapata, P. J., & Serrano, M.. Prestorage oxalic acid treatment maintained visual quality, bioactive compounds, and antioxidant potential of pomegranate after long-term storage at 2 ˚C. *Journal of agricultural and food chemistry,* **58(11):** 6804-6808 (2010).
33. Jin, P., Zhu, H., Wang, L., Shan, T., & Zheng, Y., Oxalic acid alleviates chilling

injury in peach fruit by regulating energy metabolism and fatty acid contents. *Food chemistry,* **161:** 87-93 (2014).

34. Ashraf, M. F. M. R., & Foolad, M., Roles of glycine betaine and proline in improving plant abiotic stress resistance. *Environmental and experimental botany,* **59(2):** 206-216 (2007).
35. Shan, T., Jin, P., Zhang, Y., Huang, Y., Wang, X., & Zheng, Y., Exogenous glycine betaine treatment enhances chilling tolerance of peach fruit during cold storage. *Postharvest Biology and Technology,* **114:** 104-110 (2016).
36. Creelman, R. A., & Mullet, J. E., Oligosaccharins, brassinolides, and jasmonates: nontraditional regulators of plant growth, development, and gene expression. *The Plant Cell,* **9(7):** 1211-1223 (1997).
37. Jin, P., Zhu, H., Wang, J., Chen, J., Wang, X., & Zheng, Y., Effect of methyl jasmonate on energy metabolism in peach fruit during chilling stress. *Journal of the Science of Food and Agriculture,* **93(8):** 1827-1832 (2013).
38. Zhang, Y., Chen, K. S., Chen, Q. J., Zhang, S. L., & Ren, Y. P., Effects of acetylsalicylic acid (ASA) and ethylene treatments on ripening and softening of postharvest kiwifruit. *Acta Botanica Sinica,* **45(72):** 1447-1452 (2003).
39. Kang, G. Z., Wang, Z. X., & Sun, G. C., Participation of H2O2 in enhancement of cold chilling by salicylic acid in banana seedlings. *Acta Botanica Sinica,* **45(5):** 567-573 (2003).
40. Wang, L., Chen, S., Kong, W., Li, S., & Archbold, D. D., Salicylic acid pretreatment alleviates chilling injury and affects the antioxidant system and heat shock proteins of peaches during cold storage. *Postharvest Biology and Technology,* **41(3):** 244-251 (2006).
41. Yang, Z., Cao, S., Zheng, Y., & Jiang, Y., Combined salicyclic acid and ultrasound treatments for reducing the chilling injury on peach fruit. *Journal of agricultural and food chemistry,* **60(5):** 1209-1212 (2012).
42. Wendehenne, D., Pugin, A., Klessig, D. F., & Durner, J. ,Nitric oxide: comparative synthesis and signaling in animal and plant cells. *Trends in plant science,* **6(4):** 177-183 (2001).
43. Xu, M. J., Dong, J. F., & Zhu, M. Y., Nitric oxide mediates the fungal elicitor-induced hypericin production of Hypericum perforatum cell suspension cultures through a jasmonic-acid-dependent signal pathway. *Plant Physiology,* **139(2):** 991-998 (2005).
44. Singh, S. P., Singh, Z., & Swinny, E. E., Postharvest nitric oxide fumigation delays fruit ripening and alleviates chilling injury during cold storage of Japanese plums (*Prunus salicina* Lindell). *Postharvest Biology and Technology,* **53(3):** 101-108 (2009).
45. Zhu, S., Liu, M., & Zhou, J., Effects of fumigation with nitric oxide on cell wall metabolisms of postharvest Feicheng peaches. *Zhongguo nongye kexue,* **39(9):** 1878-1884 (2006).