Journal of Agriculture and Environmental Sciences
September 2014, Vol. 3, No. 3, pp. 63-72
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jaes.v3n3a6
URL: http://dx.doi.org/10.15640/jaes.v3n3a6

Effect of Pre-Harvest Application of Paclobutrazol on Postharvest Quality of Mangoefruit (Mangiferaindicacv Manila)

Alma Vázquez-Luna[1,2], Gustavo Martínez-Castellanos[1], Eduardo Rivadeneyra-Domínguez[2] & Rafael Díaz-Sobac[1,2]

Abstract

Chemical assisted floralinduction is a common practice in manila mangoe fruit, however, the effects on post-harvest fruit quality is still notclear, hence the present study aimed to evaluate, the ripening process in mangoe fruit harvested from orchards treated with paclobutrazol (PBZ). The results showed that the use of PBZ reduced the production of ethylene and in consequence the respiration rate and processes of physical and chemical ripening. Fruit firmness from trees treated with PBZ was higher during post-harvest storage. These effects demonstrate that PBZ has a suppressor effect on fruit ripening and an important effect on post harvest life.

Keywords: Mangoe fruit, postharvest, paclobutrazol, quality

1. Introduction

The mangoe (*Mangiferaindica*cv. Manila) is an edible fruit appreciated for its attractive colour, aroma, texture and flavour. However, mango production and harvest is limited by their seasonal schedule. With a view to extending the harvest season, producers use growth regulators to manipulate flowering and the harvest time. This action allows planning for times of high demand for fresh fruit as a business strategy, creating a price advantage.

[1] Instituto de Ciencias Básicas, Lab. de Biología y Química Molecular de Frutas. Universidad Veracruzana. Av. Luis Castelazo Ayala s/n. Industrial Animas. Xalapa, Veracruz, México. C.P. 91190.
[2] Facultad de Química Farmacéutica Biológica. Universidad Veracruzana.Calle de la Pérgola s/n, Zona Universitaria, Xalapa, Veracruz, México. E-mail:almvazquez@uv.mx

Paclobutrazol (PBZ IUPAC name: (2*RS,* 3*RS*)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1*H*-1, 2, 4-triazol-1-yl) pentan-3-ol, a triazole derivative) is a plant growth regulator (PGR) widely used in this practice. It inhibits the conversion of ent-kaurene to ent-kaureneacid in the biosynthes is pathway of giberillic acid, decreasing levels of gibberellins, resulting in a reduction of elongation rate and cell division (Rademacher*et al.,*2000). The PBZ can also alter the levels of other important hormones to growth and development of fruits, such as absicic acid, ethylene,cytokine (Fletcher *et al*., 2000), auxines (Davis*et al*.,1991) and the chlorophyll synthesis (Berova and Zlatev, 2002). Although the use of PBZ to promote a reduction in vegetative growth, and an increase in yield has been widely investigated in several mangoe cultivars (Berova and Zlatev, 2003; Fernández*et al*., 2006; Singh and Bhattacherjee, 2005; Chutichudet *et al*., 2006; Silva-Cardosa*et al*., 2007; Sharma *et al*., 2011) its effects on fruit quality is not yet clear, in particular on mangoe Manila variety. Significant increases in total soluble solids (TSS), total sugars and acidity were observed in Tommy Atkins mangoe fruit when treated with PBZ(Yeshitela*et al.,* 2004). Similar results were reported by Chutichudet *et al.* (2006), who evaluating the effect of PBZ on the quality of Kaew Mangoe, showing an increase intitratable acidity and reduced TSS. Rebolledo *et al.* (2008) found that application of PBZ incultivars *Manila Cotaxtla 1* and *Manila Cotaxtla 2,* also generated an increase in the TSS, without affecting the acidity and firmness.

In México, chemical floral induction assisted is a common practice in Manila mangoe fruit production to accelerate crop harvesting and have competitive advantages in the market, however, the effects on post-harvest fruit quality is still not clear, hence the present study aimed to evaluate the ripening process in mango fruit harvested from orchards treated with paclobutrazol (PBZ).

2. Materials and Methods

2.1 Plant Materials

The study was carried out in mango orchards in Jalcomulco, Veracruz. (México), located at 96^0 55´43.4´´ west longitude, with an annual average temperature of 24^0C an annual average rainfall of 1.1 mm. The mean maximum and minimum temperature was 30.2 and 15.8 ^{0}C, respectively (INIFAP, 2011).

Eight years old mangoe trees Manilawere selected in a two plots, one was treated with paclobutrazol, it was applied at 1.5 a.i. per meter of canopy diameter before flowering. The conditions of irrigation and fertilizer were similar for both cultivars. The fruits were selected by an aleatory number criterion, after 90 days of development, in pre-climateric conditions and transported in plastic boxes to the laboratory. The experimental unit consisted of three replicates of three for each day of sampling and for every type of mangoe studied. The mangoe fruits were subjected to hydro-thermic treatment (ht) established by USDA/NOM-FITO-075. A control batch without hydrothermal treatment was evaluated during the study. The mangoe fruits were stored at 15°C and 25°C (85± 5 % R.H.) and analyzed every 2 days during 12 days post-harvest storage.

2.2 Post-Harvest Fruit Quality Evaluation

Ethylene production was analyzed using GC (Gas Chromatography) according to the method reported by Lagunes*et al.* (2007). Respiration rate, measured by the production of CO_2 was analyzed using a GC by head-space according to the method reported by Tovar*et al.* (2005), using a 6890 Hewlett Packard chromatograph equipped with a thermal conductivity detector. The CO_2 was calculated and expressed as mL CO_2 Kg^{-1} h^{-1}. The soluble solids content (SSC) in mango juice was determined using a refractometer ATAGO, Mod. Pal-1 (Atago Co., Ltd., Tokio, Japan) and the results were expressed as %. The titratable acidity was measured according to AOAC 962.12 and expressed to g of citric acid/Kg of fresh mass. Firmness was determined through a Penetrometer PNR 12 (Petrotest, Dahlewitz Germany) measuring the force to penetrate the fruit. Firmness on mangoe fruit was measured on both sides of the equatorial diameter (Vázquez-Luna *et al*., 2011). All tests were performed by triplicate.

2.3 Data Analysis

The experimental design was a randomized complete block with three replications. All data were analyzedby analysis of variance (ANOVA, $\alpha = 0.05$) using MINITAB statistical software (version 12.2) with mangoe's type treatment level. When the main effects were significant ($P<0.05$) differences between means were separated using Tukey's honestly significant difference (HSD) multiple comparison test.

3. Results and Discussion

Ethylene production over storage time for the treatment is shown in Figure 1. Mangoe fruits harvested from trees treated with PBZ showed lower ethylene production compared to control fruit. This difference was significant during 12 days of storage due to Hidrotermic Treatment (HT). However, at both 15 and 25º Cethylene production was increased to peakclimacteric, only to day 10 in the control fruit and stored hotwater immersion at 25ºC.

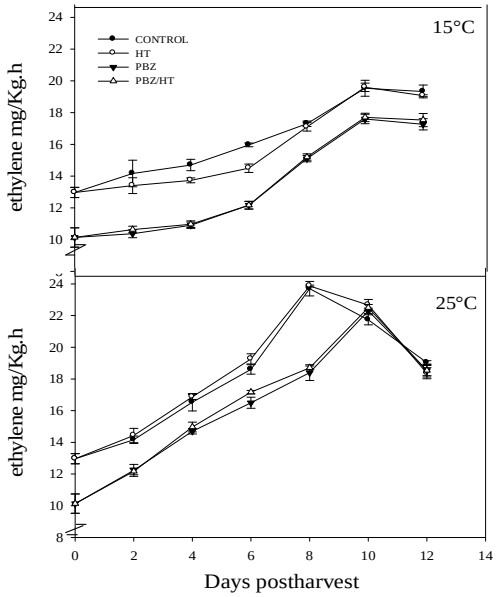

Figure 1. Ethyelene Production during Post-Harvest Storage of Manila Mangoe.

The results show that the application of PBZ reduced thy lenebiosyn thesis, which may be due to reduced synthesis of ACC by the presence of growth regulators (Masia*et al*., 1998; Min and Bartholomew, 1996). However, we observed that when immature fruits generate ethylene; an autocatalytic reaction occurs which stimulates maturation and physical and chemical changes associated with post-harvest ripening (data not presented). The respiration, estimated by CO_2 production is presented in Figure 2. Fruits stored at 15ºC showed a slow rise of CO_2 production through storage.

However, the control and HT showed significantly greater values than PBZ and PBZ–HT treatments ($P < 0.05$), ranging from 20 to 50 and 63 mg CO_2/Kg·h respectively. Control fruits showed the higher respiration rate in the last three days. On the other hand, PBZ and PBZ-HT treatments increased only 12 mg CO_2/Kg·h through all storage.

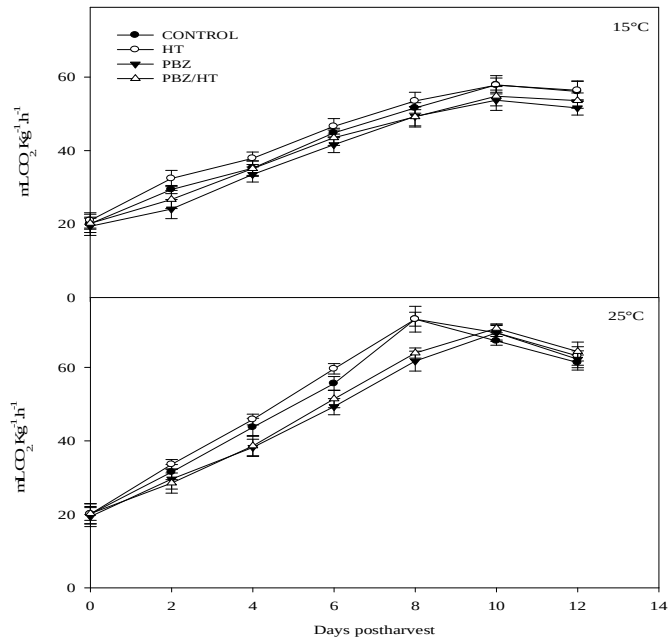

Figure 2. CO_2 Production during Post-Harvest Storage of Manila Mangoe.

The CO_2 production of mango fruits stored at 25 ºC showed that the control and HT groups showed a similar behaviour during the first 8 days of storage, showing a typical respiration rate of climacteric fruits, with an increase in the CO_2 production during the first 6 days of storage with a climacteric peak. The HT had 4 mg CO_2/Kg·h less than control group at this point and lasted 4 days more than the treated group. Fruits treated with PBZ and PBZ-HT presented lower values ($P < 0.05$) of CO_2 production during all the days of the experiment. The PBZ treatment showed the lowest concentration for the first 4 days with a rise of CO_2 production with a climacteric peak at day 6 (50 mg CO_2/Kg·h),20 mg CO_2/Kg·h less than control fruits.

On the other hand the PBZ-HT treatment showed an increase of climacteric peak at day 4, maintaining around 40 mg CO_2/Kg·h, for the next 8 days of storage. The respiration rate of PBZ and PBZ-HT treatments could be interpreted as a climacteric attenuation produced by PBZ effect. The HT treatment did not produce alteration on respiration rate at 25ºC and diminished CO_2 production for the 2 days at 15ºC. However, it improved resistance to degradation of mangoes increasing postharvest life for 4 days, more days than the control; it also reduced CO_2 production during the last for the 2 days at 15ºC. According to Bai and Chaney (2001), the PBZ can affect the electronic transport, this could promote the accumulation of NADH + H^+, in fruit cell, being able to reduce the activity of isocitrate dehydrogenase, allosteric enzyme involved in the regulation of Krebs cycle.

The change in the soluble solids contentis shown in the Table 1. At 15 °C, HT, PBZ and PBZ-HT treatments showed a slight increase from 8 to 12^0 Brix up to day 10. The control fruits developed higher concentrations through storage, increasing more than 10^0Brix. In fruits stored at 25°C, the percentage of soluble solids content (SSC), increased considerably during the development of control and HT mango fruit. PBZ and PBZ-HT treatments delayed this behaviour increasing only 4^o Brix from day 4. Jacobsen *et al.,* (1995) reported that PBZ affects gene expressions of α-amylase, which could be related to PBZ effect on soluble solids reduction. Bai and Chaney (2001) found a significant reduction on soluble solid content by pre-harvest application of 0.1%. The lower values of soluble solids could slow down the fruit metabolism by substrate availability; that could be related directly to the low CO_2 productions shown by PBZ treated fruits.

Table 1: Soluble Solids (^{0}Bx) Content During to Post-Harvest Storage of Mangoes

	Control		HT		PBZ		PBZ / HT	
days	15°C	25°C	15°C	25°C	15°C	25°C	15°C	25°C
0	8.0±0.02[a]	8.0±0.02[a]	8.0±0.1[a]	8.1±0.1[a]	7.1±0.02[a]	7.1±0.06[a]	7.1±0.10[a]	7.1±0.11[a]
2	8.1±0.11[a]	10.6±0.17[a]	8.8±0.05[a]	11.0±0.11[a]	8.5±0.05[a]	9.0±0.05[a]	8.2±0.05[a]	9.1±0.11[a]
4	10.3±0.11[a]	12.9±0.15[a]	10.6±0.17[a]	13.4±0.17[a]	10.0±0.17[a]	10.4±0.36[a]	9.9±0.15[a]	10.6±0.11[a]
6	12.4±0.25[a]	14.1±0.11[a]	12.1±0.17[a]	15.6±0.11[a]	11.9±0.11[a]	11.9±0.06[a]	11.2±0.06[a]	12.7±0.17[a]
8	13.6±0.17[a]	16.3±0.17[a]	13.5±0.05[a]	18.4±0.11[a]	12.9±0.06[a]	13.7±0.06[a]	12.9±0.11[a]	14.6±0.10[a]
10	17.3±0.05[a]	18.5±0.11[a]	15.6±0.11[a]	20.1±0.11[a]	14.7±0.11[a]	16.3±0.12[a]	14.1±0.05[a]	17.0±0.10[a]
12	20.0±0.86[a]	21.0±0.11[a]	17.5±0.05[a]	22.4±0.11[a]	15.8±0.12[a]	18.8±0.11[a]	15.6±0.11[a]	18.7±0.11[a]

Each value was obtained from the mean of three independent samples +/-SE.
Different letters denote a significant difference (α=0.05)

The acidity had a gradual decrease during the postharvest storage both at 15 as at 25ºC (Table 2). The results showed that the decrease in acidity was mainly an effect of temperature, rather than an effect from the type of treatment to which the fruit was subjected.

Table 2: Changeintitratable Acidity (G of Citric Acid/Kg of Fresh Mass) During Storage

	CONTROL		HT		PBZ		PBZ / HT	
day	15°	25°	15°	25°	15°	25°	15°	25°
0	1.89 ±0.01	1.89±0.01	1.89±0.01	1.90±0.01	2.03±0.02	2.03±0.02	2.01±0.01	2.04±0.05
2	1.79 ±0.01	1.76±0.01	1.77±0.01	1.68±0.01	1.82±0.01	1.82±0.01	1.82±0.01	1.81±0.01
4	1.50± 0.01	1.39±0.01	1.36±0.01	1.46±0.01	1.64±0.01	1.64±0.01	1.51±0.01	1.48±0.02
6	1.24± 0.01	1.13±0.01	1.09±0.006	1.18±0.01	1.36±0.01	1.36±0.01	1.22±0.01	1.20±0.01
8	1.06±0.02	0.84±0.01	0.96±0.01	0.94±0.01[a]	1.17±0.02	1.17±0.02	0.96±0.01	0.91±0.01
10	0.86±0.01	0.74±0.01	0.793±0.01	0.74±0.01[a]	0.86±0.01	0.86±0.01	0.72±0.25	0.67±0.01
12	0.76±0.01	0.66±0.01[a]	0.710±0.01[a]	0.66±0.01[a]	0.73±0.01[a]	0.73±0.01[a]	0.71±0.01[a]	0.64±0.04[a]

Each value was obtained from the mean of three independent samples +/-SE.

Fruit firmness at 15ºC was similar for all treatments until day 8 (Figure 3). PBZ and PBZ-HT treatments retained this behaviour with a small increase for the whole storage period. However, control and HT treatments showed values of 18.8 mm at day 12. Similar values to those presented at day 6 at 25 ºC. Changes in fruit softening at 25°C are presented in Figure 3b.

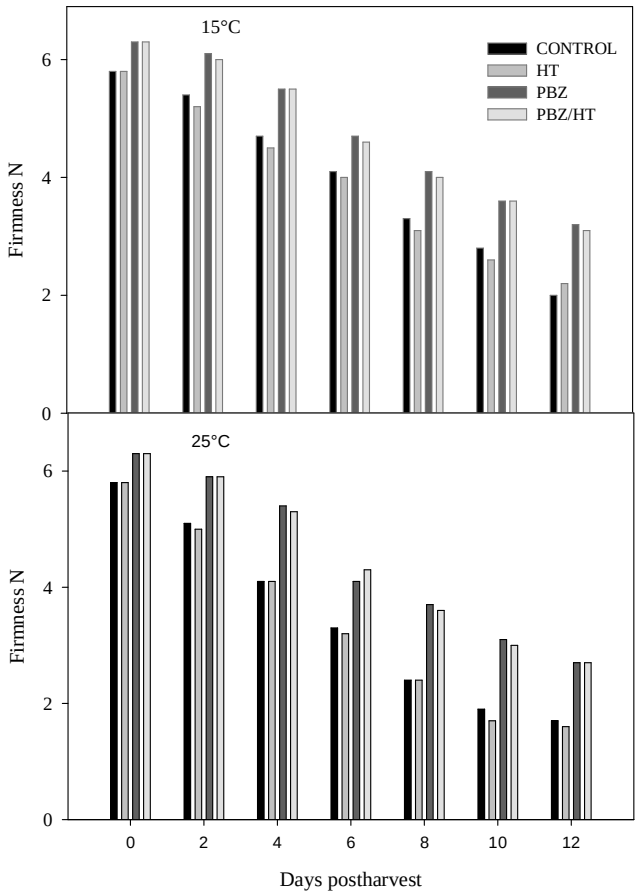

Figure 3 Firmness Loss during Post-Harvest Storage of Manila Mangoe

The firmness showed in the control and HT treatment groups confirmed that the climacteric peak coincide with firmness loss. Since the loss of structural rigidity is associated to starch, cellulosic and pecticmaterial content (Sugiyama, *et. al*, 2005. Hence, the hydrolysis of the parameters is correlated directly with the distance of penetration in the pulp of the fruits (Doreyappa and Huddar, 2001).The penetration values suggest that PBZ acted by slowing down enzymes responsible for softening.

The results show that the PBZ has a direct effect on the production capacity of ethylene, which is reduced and consequently determines the reduction of other changes associated with aging, such as respiration and physical and chemical indicators. Therefore the combination of PBZ and hydro-thermic treatment could be used to improve and maintain quality characteristics of mango during transportation.

Conclusion

Our study has shown that the PBZ reduced the ethylene production and the respiratory rate. The decrease of these parameters suggested that PBZ slowed down the ripening process. PBZ is used to manipulate flowering so as to occur earlier promote acceleration of flowering in mangoe fruit and produces early season production. In this research we found that PBZpromoted better characteristics in fruits and kept better physical appearance for a longer period. The results show that PBZ application prolonged the post-harvest life of mango.

Acknowledgments

The authors would like to P/PIFI-2011-30MSU0940B-20 Universidad Veracruzana Project for partial research grant.

Reference

AOAC. (Association of Analytical Chemists). 2010. Official Methods of Analysis, 18th ed, AOAC International,Gaithersburg, MD 20877-2417 USA.

Bai, S., and W. Chaney. 2001. Gibberellin synthesis inhibitors affect electron transport in plant mitochondria. Plant Growth Regul, 35:257-262.

Berova,M., Z. Zlatev, andN. Stovena.2002. Effect of paclobutrazol on wheat seedlings under low temperature stress. Bulg. J. Plant Physiol. 28: 75-84.

Berova, M. and Z. Zlatev.2003. Physiological response of paclobutrazol-treated triticale plants to water stress. Biol.Plantarum. 46:133–136.

Chutichudet, B., P.Chutichuda, K. Boontiang, and T. Chanaboon. 2006. Effect of chemical paclobutrazol on fruit development, quality and fruit yield of Kaew mango (Mangiferaindica L.) in Northeast Thailand. Pakistan J. Biol. Sci. 9: 717-222.

Davis, T., E. Curry, and Steffens, G.1991.Chemical regulation of vegetative growth.Crit. Rev. Plant. Sci. 10:151-158.

Doreyappa, I.N.G. andA.G. Huddar. 2001.Studies on ripening changes in mango (MangiferaindicaL.) fruits. J. Food Sci. and Technol.38: 135-137.

Fernández, J.A., L. Balenzategui, S. Bañón, and J.A. Franco. 2006. Induction of drought tolerance by paclobutrazol and irrigation deficit in Phillyreaangustifolia during the nursery period.Sci. Horticultural. 107: 277–283.

Fletcher, R., A. Gilley, N. Sankhla, and T. Davis. 2000. Triazoles as plant growth regulators and stress protectants. Horticultural Rev. 24: 55-138.

Lagunes, L., B. Tovar., M. Mata, J.C. Vinay-Vadillo, J. De la Cruz and H.S. García. 2007. Effect of exogenous ethylene on ACC content and ACC oxidase activity during ripening of manila mangoes subjected to hot wáter treatment. Plant Foods Human Nut.62:157-163-

Masia, A., M. Ventura, H. Gemma, andS. Silverio. 1998. Effect of some plant growth regulator treatments on apple fruit ripening.J. Plant Growth Regulat. 25: 127-134.

Min, X., and D.P. Bartholomew.1996.Effect of plant regulators on ethylene production, 1-aminocyclopropane-1-carboxylic oxidase activity, and initiation of inflorescence development of pineapple.J.PlantGrowthRegulat. 15: 121-128.

Norma Oficial Mexicana NOM-075-FITO-1997. Requisitos y especificaciones fitosanitarias para la movilización de frutos hospederos de moscas de la fruta. México, DF.

Rademacher, W. 2000. Growth retardants: Effect on gibberellins biosynthesis and other metabolic pathways. Annual Rev. Plant Physiol. Plant Mol. Biol. 51: 501-531.

Rebolledo-Martínez, A. A.L. Del Angel, and J. Rey-Moreno. 2008. Effects of paclobutrazol and KNO_3 over flowering and fruit quality in two cultivars of mango Manila.Interciencia. 33: 518-522.

Silva-Cardoso, M.G., A. Reboucas, A.E. Silveira, S.N. Matsumoto, and T.N. HojoReboucas.2007.Flowering and production of mango fruits (Mangiferaindica L.)cvrosa promoted by different paclobutrazol doses. Rev. Brasileira deFruticult..29:209-212.

SharmaS.K., J.K. Chauhan, and N.S. Kaith. 2011. Induction of flowering and fruiting in unproductive "Chausa" mango orchards in Himachal Pradesh. Int. J. Farm.Sci. 1:23-29.

Singh, V.K. and A.K. Bhattacherjee. 2005. Genotypic response of mango yield to persistence of paclobutrazolin soil. ScientiaHorticulturae. 106: 53-69.

Sugiyama, J., M.I. Al-Haq, and M. Tsuta. 2005**.**Application of portable acoustic firmness tester for fruits.Frutic. 5:439-443.

Tovar, B., H.S. García, and M. Mata. 2005. Evolution of carbohydrates of pre-cut slices subjected to osmotic deshydration. Plant Foods Human Nut..60: 181-186.

United States Department of Agriculture–Animal and Plant Health Inspection Services-Plant Protection and Quarantine 2002.USDA-APHIS-PPQ treatment manual02/2002-01 edition. Frederick, MD: Animal and Plant Health Inspection Service,Plant Protection and Quarantine.

Vázquez-Luna, A. F. Rivera-Cabrera, L.J. Pérez-Florés, andR. Díaz-Sobac. 2011. Effect of Rootstock on Mangoe Fruit Susceptibility to Infestation byAnastrepha oblique. J. Econ. Entomol. 104:1991-1998.

Yeshitela, T., P.J. Robbertse, andP.J.C. Stassen. 2004. Paclobutrazol suppressed vegetative growth and improve yield as well as fruit quality of "Tommy Atkins" mangoe (Mangiferaindica) in Ethiopia. New Zealand J. Crop Horticult.Sci. 32: 281-293.