DETERMINATION OF OPTIMAL ETHYLENE CONCENTRATION APPLIED IN POSTHARVEST MANGO FRUIT

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Key words: Mangifera indica L, primary metabolism, climacteric fruit, tropical fruit.

ABSTRACT

Mango is a tropical evergreen tree that is suitable for areas with cool dry winters and hot wet summers. The interest in this culture is due to the excellent fruit, having exotic flavor, and is rich in vitamins and minerals. This research project aims to determine the optimal concentration of exogenous ethylene applied to mango 'Tommy Atkins' fruits at post-harvest. The treatments were: T1 = fruits stored under uncontrolled conditions (25ºC ± 5ºC and 65% RH) without ethylene [control], T2 = fruit stored at 20ºC ± 1ºC and 90% RH with 10 ppm ethylene for 2 days, T3 = fruit stored at 20ºC ± 1ºC and 90% RH with 20 ppm ethylene for 2 days, T4 = fruit stored at 20ºC ± 1ºC and 90% RH with 40 ppm ethylene for 2 days, T5 = fruit stored at 20ºC ± 1ºC and 90% RH with 60 ppm ethylene for 2 days, T6 = fruit stored at 20ºC ± 1ºC and 90% RH with 80 ppm ethylene for 2 days and T7 = fruit stored at 20ºC ± 1ºC and 90% RH with 100 ppm ethylene for 2 days. After treatments, fruits were stored at 20ºC ± 1ºC and 90% RH (T2 to T7) and uncontrolled environmental conditions (25ºC ± 5ºC and 65% RH) for T1. Changes in firmness (N), total soluble solids (ºBrix), skin browning and rot (%) were evaluated at day 0, day 7 and day 14 after treatment. The fruits from T3 (20 ppm ethylene at 20ºC for 2 days), have the least skin browning and rots until 7th day of storage at 20ºC, and only this fruits could be marketed until this evaluation day. In conclusion, the best treatment that could help in the adequate ripening of mango 'Tommy Atkins' fruit was T3 (20 ppm ethylene at 20ºC for two days).

DETERMINACION DE LA CONCENTRACION OPTIMA DE ETILENO A SER APLICADO EN LA POSTCOSECHA DE MANGO

Palabras claves: Mangifera indica L, metabolismo primario, fruto climatérico, fruto tropical.

RESUMEN

El mango es una árbol siempre verde tropical que es cultivado desde regiones con inviernos frios e secos hasta regiones con veranos húmedos y calientes. El interés en esta planta es la excelente fruta que tiene un exótico sabor, además de ser rico en vitaminas y minerales. Este experimento busco determinar la concentración óptima de etileno exógeno que tiene que ser colocado en la postcosecha del mango 'Tommy Atkins'. Los tratamientos fueron: T1 = frutos almacenados sobre condiciones ambientales no controladas (25ºC ± 5ºC y 65% HR) sin aplicación de etileno [testigo], T2 = frutos almacenados a 20ºC ± 1ºC y 90% HR con 10 ppm de etileno por 2 días, T3 = frutos almacenados a 20ºC ± 1ºC y 90% HR con 20 ppm de etileno por 2 días, T4 = frutos almacenados a 20ºC ± 1ºC y 90% HR con 40 ppm de etileno por 2 días, T5 = frutos almacenados a 20ºC ± 1ºC y 90% HR con 60 ppm de etileno por 2 días, T6 = frutos almacenados a 20ºC ± 1ºC y 90% HR con 80 ppm de etileno por 2 días y T7 = frutos almacenados a 20ºC ± 1ºC y 90% HR con 100 ppm de etileno por 2 días. Después de los tratamientos, los frutos fueron almacenados a 20ºC ± 1ºC y 90% HR (T2 hasta T7) y sobre condiciones ambientales no controladas (25ºC ± 5ºC y 65% HR) para el T1. Cambios en la firmeza (N), sólidos solubles totales (ºBrix), pardeamiento de la casca y pudrición (%) fueron evaluados en el día 0, día 7 y día 14 después de los

tratamientos. Los frutos del tratamiento T3 (20 ppm de etileno a 20ºC por 2 días), tuvieron los menores pardeamientos de casca y pudriciones hasta el día 7 de almacenamiento a 20ºC, y solamente los frutos de este tratamiento estaban en condiciones de ser comercializados en este dia de evaluación. En conclusión, el mejor tratamiento para una maturación correcta del mango 'Tommy Atkins' fué el T3 (20 ppm de etileno a 20ºC por 2 días).

INTRODUCTION

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae, also known as the cashew family, with about 75 genera and 700 species, mostly tropical, with some subtropical and temperate species. It grows vigorously and flowers and fruits on the terminals. The mango tree flowers in late winter and is harvested in summer (Meurant et al., 1999; Nakasone and Paull, 1998).

Mango originated in the Indo-Burma region and has been cultivated in India for over 4000 years. The Portuguese, the first Europeans to establish trade routes with India, transported the mango to East Africa and Brazil. Mango is now found in all tropical areas, as well as many subtropical regions of the world, attesting to its wide range of adaptability (Nakasone and Paull, 1998).

Brazil is the seventh largest producer of mangoes, with a production of 1,197,694 t in 2010, behind only Mexico and Asian countries such as India, world's largest producer. In Brazil, the "São Paulo" is the second largest state producer of mangoes, with 15,408 ha harvested in 2005 (Anuario, 2011; FAO, 2013). Among the varieties explored, mango 'Tommy Atkins' focused aroung 90% of cropland in the country, justified, often for their hardiness, attractive color, and relative balance in production between consecutive years (Brazil, 1998; Almeida et al., 2001). However, the 'Palmer' variety presented this acreage and market share.

Mango is a climacteric fruit and ethylene can be used to reduce the time till ripening commences. In Brazil, the mango consumption is declining and domestic production is declining too (Agrianual, 2007), which can be explained, in part, without the fruit quality, and non uniform maturation, which are generally offered to the consumer. Another factor that may explain this decline is the absence, or even the limited knowledge on the various metabolic and physiological processes associated with the technical maturity and postharvest storage of mango. Depending on the conditions of the fruit and market requirements, the practice of controlled ripening can be recommended. The fruits harvested green will not ripen, and wither present white pulp. For a uniform ripening of the fruit of the mango, it applies to ethylene (C_2H_4), a phytohormone that activates the metabolic functions of the fruit and its enzymatic action, which produce the destruction of chlorophyll and emphasize more carotenoids.

Acetylene generated from calcium carbide and ethephon can also be used. Skin colour is also enhanced by ethylene treatment by increasing degreening. The best ripening temperature range is from 21 to 24ºC. At high temperatures of 32ºC, ripening can be retarded (Nakasone and Paull, 1998).

The respiratory rate gives us an idea of the overall metabolic rate of the plant (or parts of it), the mass loss, the pigments amount, the pulp firmness and the ethylene production (Maharaj et al., 1999; Saavedra del Aguila et al., 2006; Kluge et al., 2009).

There are references on the use of ethylene gas generating substances and ethylene in the maturation of several varieties of mangoes as 'Tommy Atkins' and 'Kent' (Montalvo et al., 2007). In Australia, use is 10 ppm of ethylene, at a 18-22ºC and 85-95% RH, for a period of 1-3 days (Marques et al., 2007). In Brazil, ethylene is used in a proportion of 2% of the volume of the chamber at a 22-24ºC and 85-95% HR, for a period of 3-4 days (Bleinroth, 1980). According to Medlicott et al. (1986), the

temperature range for ripening of mangoes with better quality varies from 19 to 24ºC, whereas for Saavedra del Aguila et al. (2011), the best temperature is 20ºC for application the ethylene exogenous in 'Tommy Atkins' mangoes. Despite the technical recommendations of the use of exogenous ethyelene for both the domestic and external, in order to obtain quality fruits, as serious problem of the uneven ripening of the same batch is checked in the internal trade, as well as those intendedexport. This unevenness of post-harvest ripening affect the consumer acceptance, even though in some cases the fruits have acceptable taste. Consequently, there is the loss of economic value of the fruit and not opening of foreign markets for these fruits, since the export markets are highly demanding as to quality.

The purpose of this experiment was to evaluate different ethylene concentrations during ethylene application, as well as their influence on the physicochemical parameters of 'Tommy Atkins' mango fruit, subsequently stored at 20ºC ± 1ºC or uncontrolled conditions (25ºC ± 5ºC).

MATERIAL AND METHODS

Mango fruits cv. Tommy Atkins obtained from a producer Ogata Citrus, in Taquaritinga, SP, Brazil, were used for this study. The product was sorted for uniform appearance, size and absence of physical and pathological damage.

Fruit were submitted to the following treatments:

T1= room temperature (25ºC) without ethylene (control);
T2= 10 ppm ethylene for two days at 20ºC;
T3= 20 ppm ethylene for two days at 20ºC;
T4= 40 ppm ethylene for two days at 20ºC;
T5= 60 ppm ethylene for two days at 20ºC;
T6= 80 ppm ethylene for two days at 20ºC and
T7= 100 ppm ethylene for two days at 20ºC.

The fruits were then placed into cardboard box, stored for 14 days at 20ºC and 85% RH, for T2,T3,T4,T5,T6 and T7; and room temperature (25ºC) for T1.

The variables evaluations were carried out, at zero (characterization), seven and 14 days after ethylene application or not (control). The firmness (N) was determined with digital Penetrometer Fruit Firmness Tester, before the treatments, the initial fruit firmness was 94.2 N.

The soluble solids concentration (SSC) was determined by direct reading of centrifuges in juice mango in a digital refractometer (Atago PR-101, Atago Co. Ltd., Tokyo, Japan) with the results expressed in ºBrix; the initial SSC was 7.7ºBrix.

Sking browning was determined with visual scale: 0 = without sking browning, 1 = until 3 cm^2 of sking browning, 2 = until 6 cm^2 of sking browning, 3 = until 25% of sking browning and, 4 = more 25% of sking browning; the initial sking browning was 0.6.

The rots was determined with visual evaluation in the sking, and the results expressed as percentage (%); the initial rots was 0.00 %

The data were subjected to analysis of variance and the least significant differences were calculated using SAS software for the completely randomized experimental design with four replicates (three fruits for replicate) for each day of analysis. Differences between any two treatments greater than the sum of two standard deviations were always significant ($P < 0.05$).

RESULTS AND DISCUSSION

Fruits from all treatments showed a decrease in the firmness was a reduction in all treatments, but the treatments with ethylene (T2 to T7) showed lost more firmness that treatment without ethylene (T1 – control) (Table 1). Similar results of lost firmness along the storage, were obtained in 'Tainong' mango, after 5 ppm ethylene at 25ºC for 24 hours (Wang et al., 2009); and in 'Kensington Price' mango, treated with 0.005, 0.01, 0.1, 1.0 and 10 ppm ethylene at 20ºC (Wills et al., 2001).

The softening fruit is attibuted to loss firmness of tissues and is associated with changes in cell wall composition, for changes in carbohydrates structure and composition such as pectin, hemicellulose and cellulose (Gonçalves et al., 2006). Proteins required for softening fruit hose as expansins (Sane et al., 2005), increase in volume after exogenous ethylene application, so as poligalacturanase and cellulase enzymes, show increased activity and synthesis new, after ethylene application in pre or postharvest, resulting in increased leaf and fruit abscission in the pre-harvest and loss firmness in mango postharvest.

In the present study, the response variable firmness showed is a dependent ethylene variable.

Soluble solids have varied from 9.2 to 15.2ºBrix, after ethylene application to end experiment, with no differences between T1 (without ethylene – control) and T3 (20 ppm ethylene) after 14 d of storage (Table 1). Some studies, showed variations of soluble solids from 15.2 to 17.5ºBrix in 'Kent' mango, after 500, 1500 and 2500 ppm ethrel for 3, 6 or 9 minutes at 27ºC (Yah et al., 1998); and from 10.6 to 20.5ºBrix in 'Kent' mango, after 100, 500 or 1000 ppm ethylene at 20ºC for 18 h. (Cienfuegos et al., 2004).

However, have lower soluble solids increases in 'Ataulfo' mango after 100 ppm ethrel, compared with 100 and 500 ppm for 12 hours (Montalvo et al., 2007). On the other hand, there were no soluble solids differences in 'Keitt' mango treated with 0, 500 and 1000 ppm ethrel at 28ºC for 5 minutes (Coneglian and Rodrigues, 1993). Reports that in addition to lowering starch, other changes may be observed in tropical fruit during ripening (Bleinroth, 1980).

Among them, the strength reduction due to the softening caused by increasing protopectinas solubilization, which are less carbohydrates soluble forms , yielding soluble forms, such as pectins or pectic acids. Thus, these polymers would form protopectinas with fewer Methoxyl groups, which would make the fruit less firm. Thus, the enzymes responsible for degradation of protopectinas, were found at higher levels in mature fruit there is, therefore, conditions conducive to the increase of carbohydrates in soluble forms (Coneglian and Rodrigues, 1994).

Results also observed in this experiment, the values of soluble solids, which showed significant increases with the initial value (characterization), which was 7.7ºBrix, and ending with values increased more than 100% to the initial value (Table 1).

Table 1 – Firmnnes (N) and Soluble Solids (ºBrix) in 'Tommy Atkins' manga, treated with or without exogenous ethylene (at 20ºC for 2 days) under differents concentrations of ethylene and storage at 20ºC and 90% RH (T2 to T7) or room temperature (25ºC and 65% RH – T1).

Treatment*	Storage days			
	0	7	14	CV (%)
	Firmnnes (N)			
T1	59,9 a A	15,5 a B	3,7 ab B	14,3
T2	31,4 b A	8,5 ab B	4,5 a B	10,7
T3	35,2 ab A	7,0 ab B	2,8 ab B	11,5
T4	30,7 b A	6,4 b B	2,1 ab C	12,3
T5	27,1 b A	6,0 b B	1,4 b B	11,9
T6	34,0 ab A	6,7 ab B	1,3 b B	11,3
T7	31,5 b A	6,7 ab B	1,3 b B	13,3
CV (%)	12,1	10,2	9,4	11,4
	Soluble Solids (ºBrix)			
T1	9,8 a B	15,2 a A	15,2 a A	5,3
T2	9,9 a C	14,4 ab A	13,2 bc B	4,7
T3	8,6 a B	14,3 ab A	13,8 ab A	3,9
T4	9,2 a B	13,7 b A	13,0 bc A	4,6
T5	9,7 aC	14,9 abA	13,5 bc B	5,1
T6	8,8 a C	14,7 ab A	12,2 c B	6,3
T7	8,9 a B	14,1 ab A	13,6 bc A	5,0
CV (%)	7,2	4,2	4,4	5,0

*T1 = without ethylene; T2 = 10 ppm ethylene; T3 = 20 ppm ethylene; T4 = 40 ppm ethylene; T5 = 60 ppm ethylene; T6 = 80 ppm ethylene e T7 = 100 ppm ethylene. Mean separation by small letter in column and capital letter in row by Tukey test at P ≤ 0.05.

The sking browning to T2 (10 ppm ethylene) showed higher values on the end to the experiment (Figure 1). Sking browning from 'Troi' and 'Hoi' mangoes with 0.4 or 0.8%

ethrel for 30 minutes, stored for 9 days at 20ºC or 12ºC, were obtained by Hai et al. (2009), but only in fruits stored at 12ºC, most likely the effect of storage temperature and not by the application of exogenous ethylene.

Rots on the 7th day of evaluation from the fruits of T3 (20 ppm ethylene) were the only treatment that the averaged decay below 10% threshold set to maximum in order to market this fruit (Figure 1).

The fruits from T3 (20 ppm ethylene at 20ºC for 2 days), have the more lowest sking browning and rots until 7th day os storage at 20ºC, and this fruits were the only that could be marketed (<10% rots) to this evaluation day (7th day).

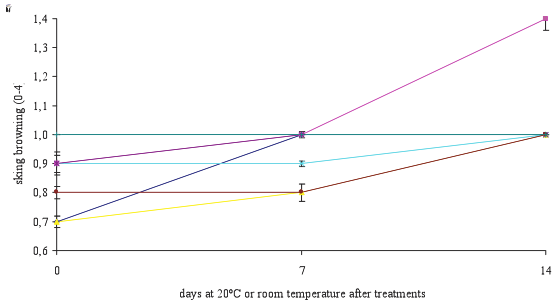

Figure 1. Sking Browning (0 = without sking browning, 1 = until 3 cm2 of sking browning, 2 = until 6 cm2 of sking browning, 3 = until 25% of sking browning and, 4 = more 25% of sking browning) and rots (%) in 'Tommy Atkins' mango fruits, under different ethylene concentrations or without ethylene (T1 = without ethylene; T2 = 10 ppm ethylene; T3 = 20 ppm ethylene; T4 = 40 ppm ethylene; T5 = 60 ppm ethylene; T6 = 80 ppm ethylene e T7 = 100 ppm ethylene) and storage. Vertical bars represent ± S.D. (n=5).

CONCLUSION

In conclusion the best treatment was T3 (20 ppm ethylene at 20ºC and 85% RH for two days), that helped in the adequate ripening of 'Tommy Atkins' mango fruit.

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