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THE EFFECT OF 1-METHYLCYCLOPROPENE (1-MCP) APPLICATION BEFORE AND AFTER CUTTING ON THE SHELF-LIFE EXTENSION OF FRESH-CUT TOMATOES

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ABSTRACT

Exposing partially ripe fruit to 1-methylcyclopropene (1-MCP) before or after cutting may be a useful supplement to proper temperature and relative humidity management for maintaining quality of fresh-cut fruit products. In this study tomato fruits were exposed to 0.5 ppm of 1-MCP for 24 hours, while tomato slices were exposed to the same concentration of 1-MCP for 6 hours. Untreated slices were used as control. Initially and after 3, 7, and 9 days of storage at 5 °C the following quality attributes were evaluated: flesh and skin color, firmness, total soluble solids content, titratable acidity and weight loss. In addition, respiration rate and ethylene production were measured. Fresh-cut tomato slices treated with 0.5 ppm of 1-MCP before cutting showed higher firmness retention than untreated slices, while slices treated after cutting showed an intermediate firmness value. Color development was delayed in both 1-MCP treated samples, which presented higher skin and flesh hue angle value compared with untreated slices. The initial decrease in skin hue angle value was reduced in slices treated either before or after cutting, while those treated after cutting showed the highest value of hue angle of the flesh. Application of 1-MCP did not affect the respiration rate, but slowed down C_2H_4 production in slices treated after cutting, compared to slices from untreated tomatoes. No significant effect of 1-MCP treatment was observed on titratable acidity, while for soluble solids content slices treated after cutting showed a value significantly higher than untreated slices. Application before processing resulted most effective for firmness retention, while all other effects were more visible when application followed cutting.

EFECTO DE LA APLICACION DEL 1-METILCICLOPROPENO (1-MCP) ANTES Y DESPUES DEL CORTE PARA PROLONGAR LA VIDA UTIL DE TOMATE FRESCO CORTADO

Palabras clave: IV Gama - *Lycopersicon esculentum* – firmeza – color - vida útil

RESUMEN

La exposición de tomate parcialmente maduro a 1-metilciclopropeno (1-MCP) antes o después del corte puede representar un método útil, sumado al control de la temperatura y humedad, para mantener la calidad del producto mínimamente procesado. En este estudio los tomates enteros han sido expuestos a 0,5 ppm de 1-MCP durante 24 horas, mientras las

rodajas se expusieron a la misma concentración durante 6 horas. Como control se utilizaron rodajas de tomate no tratadas. Inicialmente y tras 3, 7, y 9 días de conservación a 5 ºC se evaluaron los siguientes atributos cualitativos: color (piel y pulpa), firmeza, contenido en sólidos solubles, acidez titulable y pérdida de peso. Además, se midieron la tasa respiratoria y de producción de etileno.

Las rodajas de tomate tratadas con 0,5 ppm de 1-MCP antes del corte mostraron mayor mantenimiento de firmeza que las no tratadas, mientras que las rodajas tratadas después del corte han mostrado un valor intermedio de firmeza. El desarrollo del color se ha ralentizado en los dos tratamientos realizados con 1-MCP; las rodajas tratadas han mostrado un mayor valor del ángulo de tinta de la piel y de la pulpa respecto al control. La disminución inicial del ángulo de tinta de la piel se redujo en los dos tratamientos, mientras las rodajas tratadas después del corte han mostrado un mayor valor del ángulo de tinta de la pulpa. La aplicación del 1-MCP no ha afectado a la actividad respiratoria pero ha disminuido la emisión de etileno en rodajas tratadas después del corte respecto a las rodajas no tratadas con 1-MCP. No se ha observado efecto significativo del tratamiento sobre la acidez titulable, el contenido de sólidos solubles de las rodajas tratadas después del corte se ha mostrado más alto que el control.

La aplicación del 1-MCP antes y después del procesado ha resultado más efectiva para el mantenimiento de la firmeza y del color, respectivamente.

INTRODUCTION

Tomato is a natural ingredient in many salads and its use as a fresh-cut product is still very limited due to its short shelf-life when processed. The use of fresh-cut tomato by fast-food restaurants, food service institutions, and cafeterias is also limited by technical problems in maintaining its microbiological safety during storage (Hong and Gross, 2002). Some studies have been conducted on the physiological and biochemical responses of excised tomato tissue (Gross and Saltveit, 1982; Edwards et al., 1983). Accelerated loss of texture is considered one of the main factors that limit the shelf-life of fresh-cut tissue (King and Bolin, 1989; Beaulieu and Gorny, 2001). The texture breakdown of minimally processed tissue is expected to occur as a response to a wound-induced increase in enzymes targeting cell walls and membranes (Huber et al., 2001). The effect of slicing on the postharvest behaviour of fresh cut tomato slices includes a rapid rise in CO_2 and C_2H_4 production which reduced shelf-life (Mencarelli and Saltveit, 1988; Mencarelli et al., 1989; Artés et al., 1999). Most of the defects of fresh cut tomatoes observed during processing and storage are represented by juice accumulation, seed germination and moisture condensation.

Exposing partially ripe fruit to 1-MCP before cutting or after cutting may be a useful supplement to proper temperature and relative humidity management for maintaining quality of fresh-cut fruit products. The reported effect of 1-MCP on fresh-cut products is rather variable. Its application on fresh-cut apples decreased ethylene production, respiration rate, softening, color change and synthesis of aroma compounds (Jiang and Joyce, 2002; Bai et al., 2004; Calderón-López et al., 2005). Colelli and Amodio (2003) found suppression of respiration rate and ethylene production in sliced kiwifruit treated with 1 ppm 1-MCP for 6, 12, 24 hours.

Vilas-Boas and Kader (2007) found different responses in firmness, color, and CO_2 and C_2H_4 production depending on the 1-MCP application (1 ppm of 1-MCP for 6 h at 10 °C) to kiwifruit, persimmon, and mango before (whole fruit) and after cutting (slices).

A study was conducted to determine the effect of 1-MCP (1 ppm for 24 h at 5 °C) on textural changes in fresh-cut tomato slices during storage at 5 °C (Jeong et al., 2004). 1-MCP showed a significant effect on firmness of fresh-cut *light-red* tomato slices, during storage at 5

°C for 10 days, while had no affect on the firmness of fresh-cut *red* tomato slices at 5 °C or on slices prepared from 5 °C-stored intact *red* tomatoes.
The aim of this study was to determine the potential of using 1-MCP before or after cutting for extending the shelf life of fresh-cut tomatoes.

MATERIALS AND METHODS

Tomato berries (*Lycopersicon esculentum* mill. Cv. Caramba) were harvested at the *light red-red* stage of ripening, according to the usda standard tomato color classification chart (USDA, 1991) and transported to the Postharvest Laboratory at the University of Foggia. About 100 tomatoes were sorted to remove damaged, defective, and overripe fruits. Ten berries were used for initial determinations, while other 30 tomatoes were divided in 3 lots of 10 fruits. Each lot was then placed in a 6280-mL container, sealed, and placed in a cold room at 15 °C. Gaseous 1-MCP (22 mL from a 125 ppm stock solution) was injected in each of 3 containers in order to obtain a final concentration of 0.5 ppm in the headspace. After 24 hours, all containers were opened and exposed to fresh air. Tomatoes were cut into slices which were randomly divided in 9 lots (3 replicates x 3 storage durations) with 10 slices for lot, held in 9420-ml containers and connected to a continuous flow of humidified air in cold room at 5 °C.

Other 30 berries (as untreated control) were cut into slices which were randomly divided in 9 lots (3 replicates x 3 storage durations) with 10 slices for lot, held in 9420-mL containers and connected to a continuous flow of humidified air in cold room at 5 °C.
The remained 30 tomatoes were used for 1-MCP application as a fresh-cut product. Berries were cut into slices which were randomly divided in 9 samples (3 replicates x 3 storage durations) of 10 fruits. Groups of 3 samples (one sample x storage duration) were then placed in a 9420-mL container, sealed, and placed in a cold room at 15 °C.

Gaseous 1-MCP (15 mL from a 250 ppm stock solution) was injected in each of 3 containers in order to obtain a final concentration of 0.5 ppm in the headspace. After 6 hours, all containers were opened and exposed to fresh air and connected to a continuous flow of humidified air in cold room at 5 °C.

Initially and after 3, 7, and 9 days of storage at 5 °C, the following quality attributes were determined:

- flesh and skin color, measured with a minolta tristimulus colorimeter (Model CR-300, Minolta, Osaka, Japan) in the CIEL*a*b* mode;
- firmness, measured on each slice using an Instron Universal Testing Machine, model 1140, equipped with two flat plates. The force (N) required to deform the slices surface of 1.5 mm was recorded;
- soluble solids of the juice (TSS), measured with an atago digital refractometer and expressed in °Brix;
- titratable acidity (TA), by titrating 5 g of juice with 0.1N NaOH to a phenophtalein endpoint (pH 8.1), and expressed as % of citric acid;
- weight loss as percentage.

In addition, respiration rate (mL CO_2/kg*h) and ethylene production (µL C_2H_4/kg*h) were measured using a closed system. The increase in CO_2 and C_2H_4 content in the headspace was measured after closing the jars and then taking gas samples from the headspace with a syringe. Gas samples were then injected into a gas chromatograph (Shimadzu, model 17A ATF) equipped with a thermal conductivity detector and a flame ionization detector to measure carbon dioxide and ethylene concentrations respectively, which were then referred to the sample weight, to the free volume in the jars, and to the elapsed time.

Analysis of variance (ANOVA) was performed on raw data in order to detect statistical differences between treatments for each quality attribute. Where the case, duncan multiple range test (DMRT) was used for mean separation.

RESULTS AND DISCUSSION

Exposure to 1-MCP effectively slowed down the softening of fresh-cut tomato slices stored for 9 days at 5 °C; the effect on firmness resulted more pronounced if 1-MCP was applied before cutting as it is shown in table 1, where mean values for all storage durations are reported.

Table 1. Effects of 1-MCP on quality attributes of fresh-cut tomatoes stored for 9 days at 5 °c. Mean values of 9 lots from all storage durations. (for each line, different letters indicate significant differences for p= 0.05 according to dmrt).

***Tabla 1**. Efecto del 1-MCP sobre los atributos cualitativos de tomate cortado fresco conservado durante 9 días a 5 °C. Valores medios de 9 lotes relativos a todas las pruebas (En cada fila las distintas letras indican diferencia estadísticamente significativa para P=0,05 según DMRT).*

Attributes	CTRL		1-MCP BEFORE CUTTING		1-MCP AFTER CUTTING	
Firmness (N)	83.17	b	104.04	a	90.19	ab
L* flesh	40.62	ns	39.67	ns	40.62	ns
a* flesh	28.87	ns	29.62	ns	29.31	ns
b* flesh	31.72	c	32.88	b	33.78	a
Hue Angle flesh	0.83	b	0.837	b	0.86	a
Chromaticity flesh	42.93	b	44.29	a	45.09	a
L* skin	28.94	b	30.18	a	30.29	a
a* skin	23.32	ns	23.39	ns	22.66	ns
b* skin	34.52	b	36.40	a	36.64	a
Hue Angle skin	0.98	b	1.00	a	1.02	a
Chromaticity skin	41.72	b	43.34	a	43.14	a
Soluble Solids (° Brix)	4.63	b	4.69	ab	4.79	a
Titratable acidity (% citric ac.)	0.32	ns	0.36	ns	0.33	ns
Weight loss (%)	1.43	b	2.95	a	1.73	b
Respiration (ml CO_2/kg*h)	50.70	ns	37.02	ns	36.34	ns
Ethylene (µl C_2H_4/kg*h)	35.80	a	29.63	ab	23.40	b

Considering the data for each sampling, firmness decreased during storage for all treatments (figure 1), slices from berries exposed to 0.5 1-CP before cutting showed the highest force required for deformation throughout all the experiment, while slices from untreated berries showed the lowest. Differences between samples were small but consistent but while aggregated data resulted statistically different, no statistical significance was observed for each storage duration.

These results are in agreement with other authors. Jeong et al. (2004) reported that tomato slices prepared from *light-red* fruit exposed to 1-MCP (1 ppm for 24 h at 5 °C) retained significantly higher pericarp firmness than slices from untreated fruit. Vilas-Boas and Kader (2007) and Jiang and Joyce (2002) observed that 1-MCP was effective in delaying the softening of fresh-cut persimmon and apple slices when applied on intact fruit before processing. Jiang et al. (2001) also found that exposure of whole strawberries to 0,01-1.0 µL L^{-1} 1-MCP at 20 °C slowed loss of firmness. In addition, 1-MCP delayed the softening of mango slices when applied after processing, and of kiwifruit slices when applied either before or after processing (Vilas-Boas and Kader, 2007).

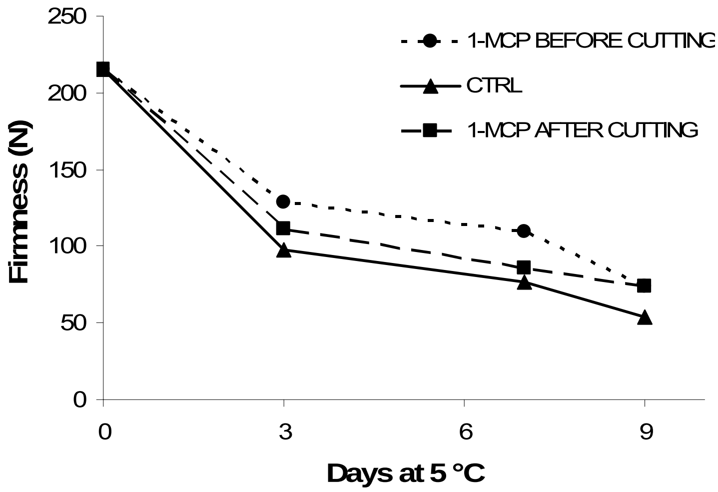

Figure 1. Effects of exposure to 1-MCP on firmness of fresh-cut tomatoes stored for 9 days at 5 °C.

Figura 1*. Efecto del 1-MCP sobre la firmeza de tomate cortado fresco conservado durante 9 días a 5 °C.*

1-MCP treatment delayed color development, as shown in Table 1. Both 1-MCP treated samples (before and after cutting) showed higher skin and flesh hue angle value compared with control slices. For untreated slices skin hue angle decreased during the first 3 days of storage at 5 °C, remaining more or less unchanged until the end of experiment. These changes were significantly reduced in 1-MCP treated tomatoes, with no differences between berries treated before or after cutting (Figure 2). Similar pattern was observed for flesh color, with a significant higher hue angle value for tomatoes treated after cutting, although in this case a major initial decrease for all treatments was observed.

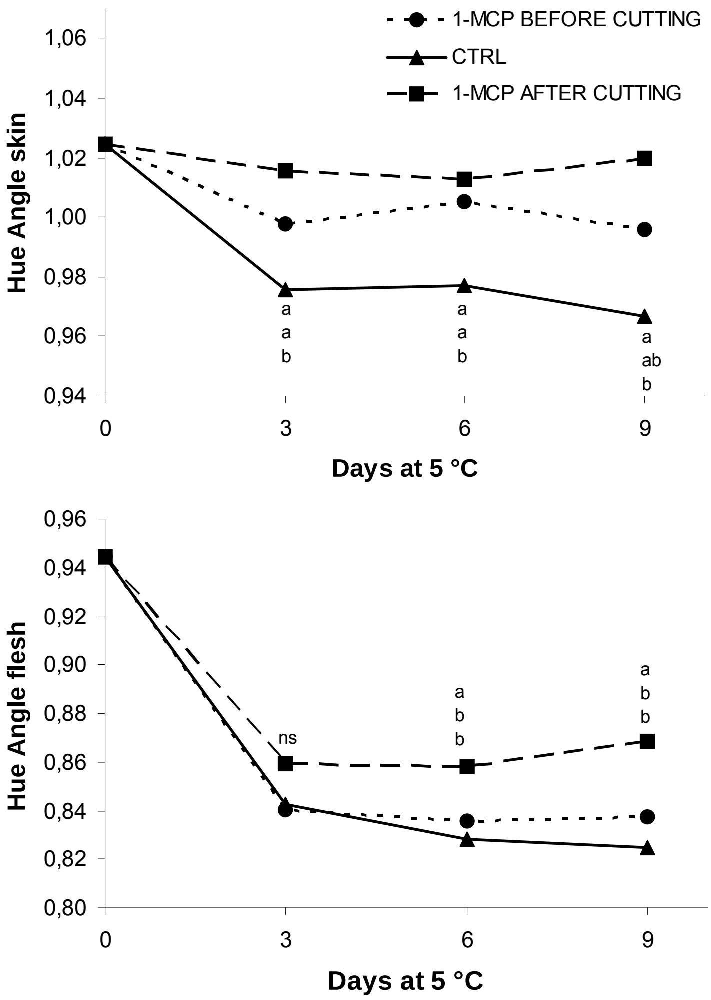

Figure 2. Effects of exposure to 1-MCP on hue angle of fresh-cut tomatoes stored for 9 days at 5 °C. (For each storage duration different letters indicate significant differences according to DMRT for P=0.05).

***Figura 2**. Efecto del 1-MCP sobre el ángulo hue de tomate cortado fresco conservado durante 9 días a 5 °C. (En el gráfico, para cada tiempo de conservación, las distintas letras indican diferencias significativas para P=0,05 según DMRT).*

Application of 1-MCP, either before or after processing, did not determine significant difference on respiration rate of fresh-cut tomato slices stored for 9 days at 5 °C, in relayion to mean values for all storage durations (Table 1). However, differences between treatments were observed during storage. Slices from untreated berries always presented higher respiration rates compared to 1-MCP treated tomatoes (before or after cutting), the difference resulting statistically significant up to 5 days of storage (Figure 3). Difference between the two 1-MCP application treatments did not result consistent throughout the experiment.

C_2H_4 production resulted significantly higher for slices from untreated tomatoes compared to slices treated with 1-MCP after cutting. Slices from berries treated with 1-MCP before cutting had an intermediate mean value (Table 1); data for each sampling throughout the experiment showed the same behaviour, with difference resulting statistically significant at day 3 and 6 (Figure 3). In any case treating with 0.5 ppm of 1-MCP tomato slices after cutting consistently lowered ethylene production.

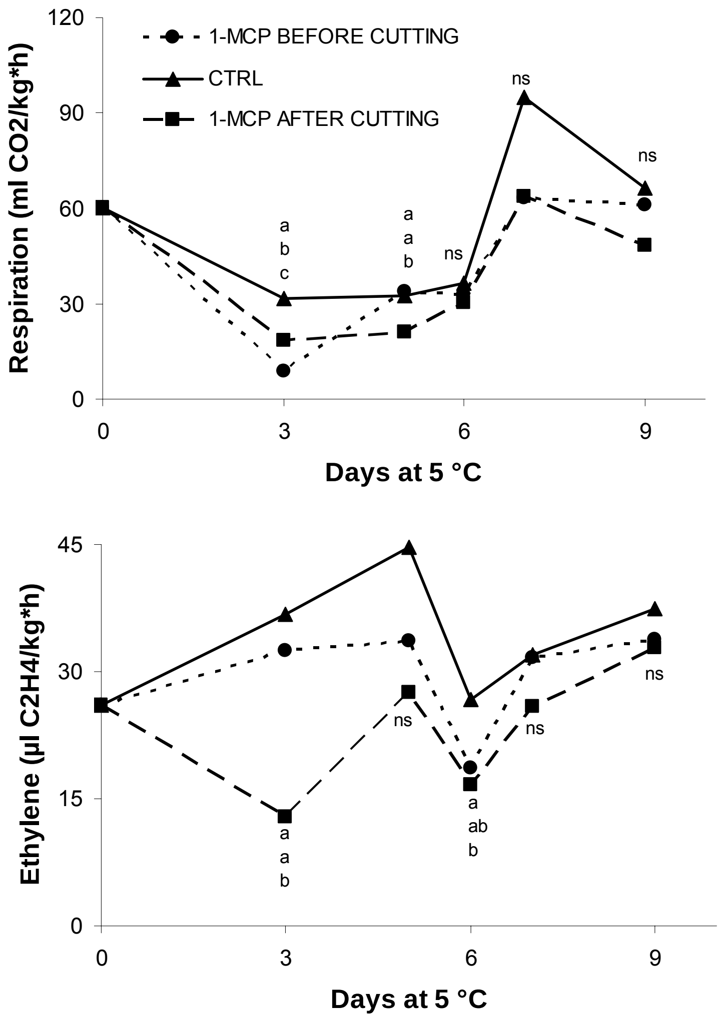

Figure 3. Effects of exposure to 1-MCP on respiration rate and ethylene production of fresh-cut tomatoes stored for 9 days at 5 °C. (For each storage duration different letters indicate significant differences according to DMRT for P=0.05).

***Figura 3**. Efecto del 1-MCP sobre la actividad respiratoria y la emisión de etileno de tomate cortado fresco conservado durante 9 días a 5 °C. (En el gráfico, para cada tiempo de conservación, las distintas letras indican diferencias significativas para P=0,05 según DMRT).*

In a similar experiment on fresh-cut persimmons Vilas-Boas and Kader (2007) found highest ethylene production in slices treated with 1 ppm of 1-MCP for 6 h at 10 °C before cutting, while no significant difference was observed between the ethylene production rates of slices treated after cutting and slices obtained from untreated fruits.

In the same work, they also reported that for fresh-cut kiwifruit and mango, 1-MCP treatments (before or after cutting) reduced C_2H_4 production during the last 3 days in comparison with the untreated control. Colelli and Amodio (2003) found suppression of respiration rate and ethylene production in sliced kiwifruit treated with 1 ppm 1-MCP for 6, 12, 24 hours. In apple slices, Jiang and Joyce (2002) observed a slightly reduced respiration rate as a response to 1-MCP (1 ppm for 6 h) treatment (either applied before and after cutting), and a markedly reduced ethylene production when 1-MCP was applied before cutting. Budu and Joyce (2003) found that 1-MCP reduced respiration rate of pineapple slices.

No significant effect of 1-MCP treatment was observed on titratable acidity (Table 1), while total soluble solids resulted lowest for control slices and highest for tomato treated after cutting (Table 1), although no significant differences were observed for each storage duration.

CONCLUSIONS

Exposing ripe fruit to 1-MCP before or after cutting may be a useful supplement to proper temperature and relative humidity management in order to maintain quality of fresh-cut fruit products. The application of 0.5 ppm of 1-MCP delayed softening, color evolution, and soluble solids increase, and lowered respiration rate and ethylene production. Application before processing resulted most effective for firmness retention, while all other effects were more visible when application followed cutting.

From a practical point of view, treating intact fruit is much more practical than handling the slices, although the latter may result in stronger 1-MCP effect.

REFERENCES

Artés, F.; Conesa, M.A.; Hernández, S.; Gil, M.I. Keeping quality of fresh-cut tomato. Postharvest Biol. Technol., v.17, n.3, p.153-162, 1999.

Bai, J.; Baldwin, E.A.; Soliva Fortuny, R.C.; Matthesis, J.P.; Stanley, R.; Perera, C.; Brecht, J.K. Effect of pretreatment of intact 'Gala' apple with ethanol vapor, heat, or 1-methylcyclopropene on quality and shelf life of fresh-cut slices. J. Am. Soc. Hort. Sci., v.129, p.583-593, 2004.

Beaulieu, J.C.; Gorny, J.R. 2001. Fresh-Cut Fruits. p.1-49. In: Gross, K.C.; Saltveit, M.E.; Wang, C.Y. (eds.). The commercial storage of fruits, vegetables, and florist and nursery stocks. USDA Handbook 66, USDA, Washington, D.C.

Budu, A.S.; Joyce, D.C. Effect of 1-methycyclopropene on the quality of minimally processed pineapple fruit. Aust. J. Exp. Agric., v.43, p.177-184, 2003.

Calderón-López, B.; Bartsch, J.A.; Lee, C.Y.; Watkins, C.B. Cultivar effects on quality of fresh cut apple slices from 1-methylcyclopropene (1-MCP)-treated apple fruit. J. Food Sci., v.70, p.114-118, 2005.

Colelli, G.; Amodio, M.L. Effetti del trattamento con 1-metilciclopropene (1-MCP) su frutti di actinidia interi e a fette. Riv. di Frutticoltura, v.65, n.3 p.61-68, 2003.

Edwards, J.; Saltveit, M.E.; Henderson, W.R. Inhibition of lycopene synthesis in tomato pericarp tissue by inhibitors of ethylene biosynthesis and reversal with applied ethylene. J. Am. Soc. Hort. Sci., v.108, p.512-514, 1983.

Gross, K.C.; Saltveit, M.E. Galactose concentration and metabolism in pericarp tissue from normal and non ripening tomato fruit. J. Am. Soc. Hort. Sci., v.107, p.328-330, 1982.

Hong, J.H.; Gross, K.C. Maintaining quality of fresh-cut tomato slices through modified atmosphere packaging and low temperature storage. J Food Sci., v.66, p.960-965, 2001.

Huber, D.J.; Karakurt, Y.; Jeong, J. Pectin degradation in ripening and wounded fruits. Rev. Bras. Fisiol. Veg., v.13, p.224-241, 2001.

Jeong, J.; Brecht, J.K.; Huber, D.J.; Sargent, S.A. 1-Methylcyclopropene (1-MCP) for maintaining texture quality of fresh-cut tomato. HortScience, v.39, n.6, p.1359-1362, 2004.

Jiang, Y.; Joyce, D.C.; Terry, L.A. 1-methylcyclopropene treatment affects strawberry fruit decay. Postharvest Biol. Technol., v.23, p.227-232, 2001.

Jiang, Y.; Joyce, D.C. 1-Methycyclopropene treatment effects on intact and fresh-cut apple. J. Hort. Sci. Biotechnol.,v. 77, p.19-21, 2002.

King, A.D.; Bolin, H.R. Physiological and microbiological storage stability of minimally processed fruits and vegetables. Food Technol., v.2, p.132-135, 1989.

Mencarelli, F.; Saltveit, M.E. Ripening of mature-green tomato fruit slices. J. Am. Soc. Hort. Sci.,v.113, p.742-745, 1988.

Mencarelli, F.; Saltveit, M.E.; Massantini, R. Lightly processed foods: Ripening of tomato fruit slices. Acta Hort., v. 244, p.193-200, 1989.

Vilas-Boas, E.V de B.; Kader, A.A. Effect of 1-methylcyclopropene (1-MCP) on softening of fresh-cut kiwifruit, mango and persimmon slices. Postharvest Biol Technol., v.43, n.2, p.238-244, 2007.

USDA. 1991. U.S. Standards for Grades of Fresh Tomatoes. USDA, Agr. Mktg. Serv., Washington, DC. Available in http://www.ams.usda.gov/standards/tomatfrh.pdf, downloaded November 2006.