South Western Journal of Horticulture, Biology and Environment
P-Issn: 2067- 9874, E-Issn: 2068-7958

Vol.4, No.2, 2013
pp.103-115

EFFECT OF CALYX REMOVAL AND DISINFECTION ON RIPENING RATE AND CONTROL OF POSTHARVEST DECAY OF TOMATO FRUIT

Sedighe Sadat KHALEGHI[1]*, Naser ALAMZADE ANSARI[1] and Seied Mohammad Hasan MORTAZAVI[1]

1. Department of Horticultural Science, College of Agriculture, Shahid Chamran University, Ahvaz, Islamic Republic of Iran.
*Corresponding author: khaleghi1360@yahoo.com

Abstract. *Tomato is one of the most important fruit vegetables. Softening and decay are the main factors of tomato fruit postharvest losses. In this work, the effects of disinfection with 0.85% sodium chloride (NaCl) and storing with or without calyx on postharvest ripening and decay control of two tomato cultivars, viz: Chef and Sunseed were studied. Fruits that were harvested at mature green stage and after treatment; they were stored at 16°C and RH 80% for 35 days. Quality parameters including firmness, weight loss, vitamin C, chlorophyll and carotenoid content and decay percentage were analyzed at 7 days intervals. The results showed that calyx removal delayed the ripening rate by reducing the fruit softening, weight loss, chlorophyll degradation and carotenoid formation, but fruit ripening accelerated in fruits treated with NaCl. Postharvest decay, a major quality parameter used in this experiment, significantly reduced in calyx-removed fruits and controlled by NaCl treatment.*

KEYWORDS*: Calyx removal, Disinfection, Ripening rate, Decay, Tomato.*

INTRODUCTION

Tomato (*Licopersicum esculentum* L.) is one of the most important and a widely cultivated vegetable in Iran, but due to lacking of appropriate post

harvest technologies and transport system, it faces considerable post harvest losses. In tropical countries, a loss of 20-50% has been reported for fresh tomatoes during harvest, transport and consumption process (Pila et al. 2010). There are numerous factors affecting postharvest losses of fruits and vegetables including diseases caused by fungi and bacteria. Disinfection of tomatoes with sodium hypochlorite before packaging greatly reduced subsequent microbial spoilage (Smid et al. 1996, Hang and Gross 1998). However, chemicals have been effectively used to reduce the incidence of postharvest disease but economical and environmental problems or health concerns for these materials have prompted to the evaluation and using of natural antimicrobial compounds. The antimicrobial effects of sodium chloride (NaCl) as a low toxicity agent have been indicated by several studies and it can be an interesting candidate for application as a surface disinfection for fresh fruits and vegetables (Cliver 2003).

In several countries, calyx is regarded as an indicator of freshness and quality of tomato fruit, and its removal is undesirable (Smid et al. 1996). In addition, consumers are highly attracted to the tomato aroma providing by the green part of the fruit (Bustan et al. 2007). However, calyxes are usually the first part of the tomatoes on which visible growth of fungi appears. The highest bacterial and fungal counts were detected in samples with the calyx attached to the fruit. Thus, calyx is the main source of potential spoilage microorganisms of tomato fruit (Smid et al. 1996). In respect to that, the stem scar is the site of gaseous exchange, so removal of attached peduncle causes the delay in ripening rate by decreasing internal O_2 and increasing CO_2 level (Thompson 2003). This study was conducted to determine the effect of calyx removal and disinfection on ripening rate and control of postharvest decay of tomato fruit

MATERIALS AND METHODS

Plant material. Four hundred and thirty two tomatoes of two cultivars, viz: (i) ‘Chef’ and (ii) ‘Sunseed’ were harvested at mature green stage from plants grown in a commercial field in Ahvaz, Khuzestan province, Iran. Fruits were transported to the

lab and graded for uniform shape and size and with no apparent mechanical injuries, insects or diseases. Samples were washed with tap water and then air-dried and prepared for treatments.

Treatments. Samples divided into the two groups, one of them was disinfected by submerging in 0.85% NaCl solution for 30 minutes and another group was used untreated as samples for control. After drying fruits under ambient air, the calyx part was removed from half fruits of each group. Then treated samples were packed in perforated plastic bags and stored at 16°C with 80% RH for 35 days. Fruits were analyzed at 7 days intervals for firmness, weight loss, vitamin C, chlorophyll content, carotenoid content and decay percentage.

Measurements. Firmness was assayed using a hand penetrometer (5mm probe). Fruits were pierced at opposite sides of their equatorial axes. Weight loss of tomato fruits was calculated by considering the differences between initial and final weight divided by their initial weight. Chlorophyll and carotenoid content were determined by spectrophotometric method according to Bajracharya (1998). One gram of tomato fruit was extracted with 10 ml of 80% acetone, and then the extract absorbance was recorded at 470, 654 and 663nm. Total chlorophyll and carotenoid were expressed as mg per g of fresh tissue. Vitamin C content was determined with the titration of filtrate against 2, 6 dichlorophenol indolphenol and expressed as mg per 100g of fresh tissue (Ranaganna 1997). The decay of the stored tomato fruits was determined by visual observation and calculated as the number of decayed fruit divided by initial number of all fruits (Pila et al. 2010).

Statistical Analysis. Analysis was performed using a completely randomized design, with 8 treatments arranged in a factorial scheme and 3 replicates. Data were analyzed using SAS (statistical analysis system) software. Analysis of variance (ANOVA) and Duncan's multiple range tests were used to compare significance of the difference between the samples. Values were expressed as means± standard error.

RESULTS

Firmness

As shown in Figure 1, fruit firmness had decreased in both cultivars during

storage. Calyx removal was effective in delaying of fruit softening, especially when fruits were not disinfected with NaCl solution. Differences in fruit firmness were significant up to 21 days after storage.

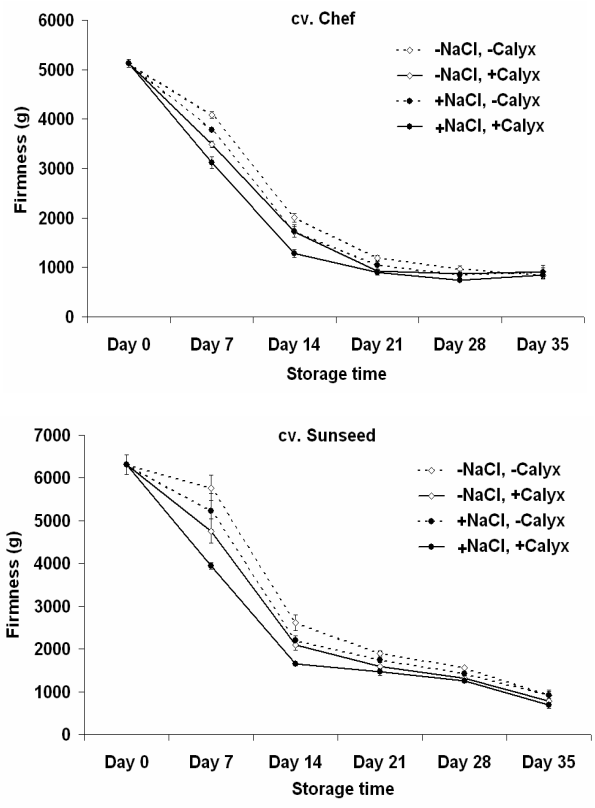

Figure 1. Effect of calyx removal and disinfection with NaCl on fruit firmness of two tomato cultivars during 35 days storage at 16°C. Vertical error bars on data points represent the ±SE of the mean.

Weight Loss (WL)

As expected, weight loss had increased during storage for both cultivars. Fruits of cv. Chef exposed to more weight loss than Sunseed fruits and they lost 13.35 and 8.94% of their initial weights respectively at the end of

the experiment (Figure 2). Weight loss was affected by NaCl treatments and disinfected fruits had significantly higher losses of weight during storage. In addition, fruits with calyx showed lower WL than fruits without calyx. At the end of the experiment, maximum WL was recorded in fruits that had calyx and treated with NaCl (13.17% for cv. Chef and 20.96% for cv. Sunseed).

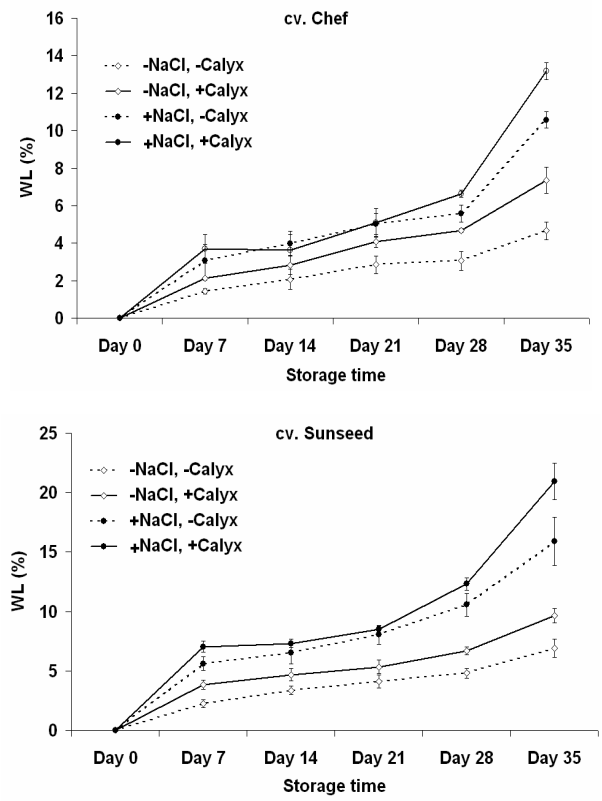

Figure 2. Effect of calyx removal and disinfection with NaCl on fruit weight loss of two tomato cultivars during 35 days storage at 16°C. Vertical error bars on data points represent the ±SE of the mean.

Chlorophyll and Carotenoid content

However mature green fruits were selected for this experiment, but they lost their surface color in almost all treatments as storage progressed. Determination of chlorophyll content showed that degreening in fruits with calyx and disinfected was faster than other fruits and it was more sever at first and second week that then continued with slower rate. Chlorophyll degradation pattern was similar for both cultivars and reached to about 8.3 µg/g FW after 35 days storage period. Changes in carotenoid content showed the opposite pattern, and from the initial value of 2.86 mg/g FW increased to average of 19.40 and 18.98 mg/g FW for Chef and Sunseed, respectively. More carotenoid content was seen in fruits with calyx and treated with NaCl. Negative correlation of changes in fruit chlorophyll and carotenoid content indicates that removal of calyx delayed degradation of chlorophyll and the development of carotenoid (Figure 3).

Vitamin C content

Vitamin C content in both cultivars was higher at the end of the storage period than its initial value. Vitamin C content increased in all treatments and the highest values were found at 35 days after storage at 16°C (Averaged 9.62 and 14.64 mg/100 g FW for Sunseed and Chef Cultivars, respectively). In addition, removal of calyx significantly increased the vitamin C content of tomato fruits. Fruits disinfected with NaCl without calyx showed more vitamin C in compared with similar fruits with calyx (Figure 4).

Decay

After the second and third week of storage, symptoms of decay appeared in Chef and Sunseed fruits, respectively. Fruits without calyx and disinfected with NaCl had the lowest decay level, and they showed no symptoms until the end of the storage period. In contrast, the highest level of decay was recorded for fruits containing calyx and did not treat with NaCl solution (21.6% and 18.6% decay for Chef and Sunseed cultivars, respectively at the end of the experiment) (Figure 5).

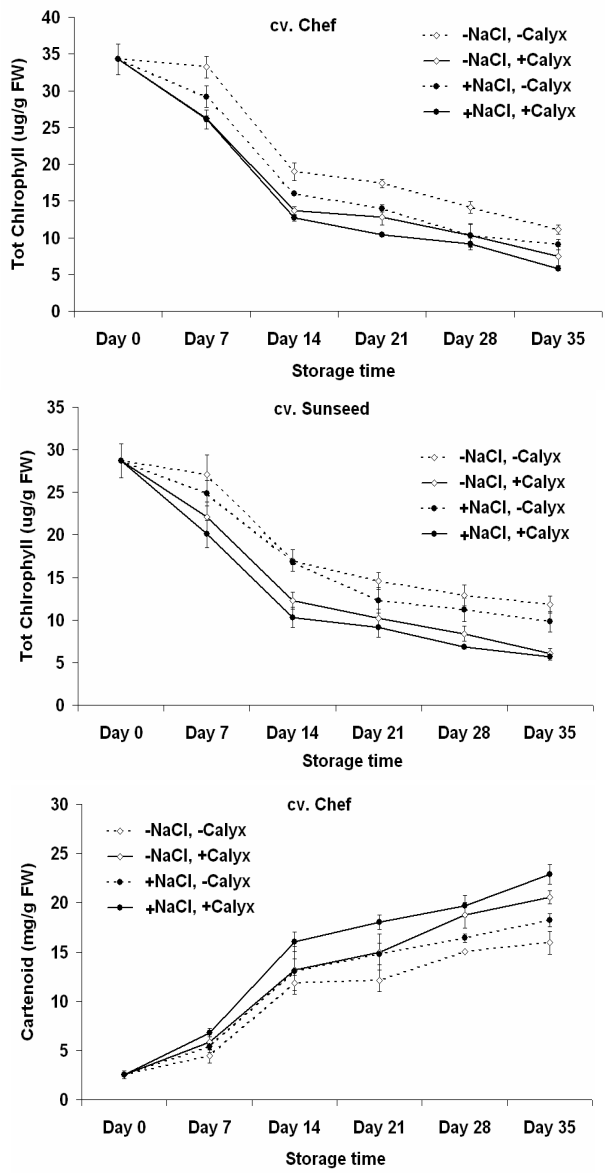

Figure 3. Effect of calyx removal and disinfection with NaCl on fruit chlorophyll and carotenoid content of two tomato cultivars during 35 days storage at 16°C. Vertical error bars on data points represent the ±SE of the mean.

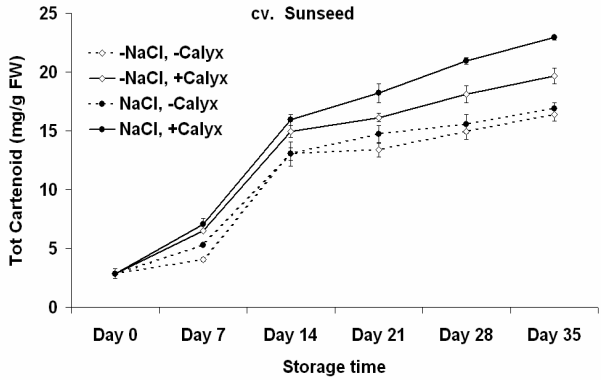

Figure 3 [continued]. Effect of calyx removal and disinfection with NaCl on fruit chlorophyll and carotenoid content of two tomato cultivars during 35 days storage at 16°C. Vertical error bars on data points represent the ±SE of the mean.

DISCUSSION

This study showed that calyx removal delayed ripening rate by delaying softening, weight loss, and degradation of chlorophyll and accumulation of carotenoid. These results are in agreement with Yang and Shewfelt (1999) that reported sealing of stem scar of tomato greatly reduced the ripening rate and extended fruits storage life. Ilic and Fallik (2007) showed that peduncle-calyx removal of tomato fruits increased the storage life. In addition, Paul and Sirvastava (2006) indicated that tomato var. Pusa Gaurav had slower ripening rate in comparison to var. Pusa Ruby, which might be due to lesser surface area of stem scar region. Since, majority of gas exchange (up to 97%) for tomato fruit occurs through the stem scar region, so this delay in ripening can be linked to internal increase in CO_2 level and concurrent decrease in O_2 level (Paul and Sirvastava 2006). Possibly lower O_2 to CO_2 ratio within the fruit microenvironment contributed for lower respiratory activity and thereby slower rate of ripening. Inhibition of respiration, in particular by low O_2 to CO_2 ratio, may be due to reduced activity or synthesis of various enzymes of the respiratory metabolism. In addition, under condition of low oxygen, activities of fruit softening enzymes

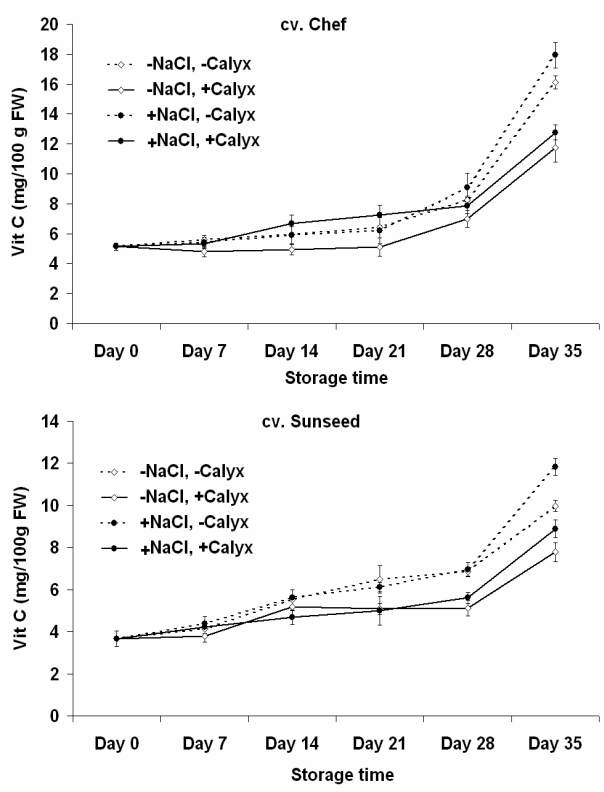

Figure 4. Effect of calyx removal and disinfection with NaCl on fruit vitamin C content of two tomato cultivars during 35 days storage at 16°C. Vertical error bars on data points represent the ±SE of the mean.

i.e. cellulase and polygalactronase is reduced (Paul and Sirvastava 2006). Thus, delay in fruit softening can be attributed to lower internal oxygen after calyx removal. The result of this study showed that weight loss was reduced in calyx-removed fruits. As calyx is an important route of water loss (Diaz-Preze 1998) our result can be valid. Also in tomato fruit, water loss through the calyx or stem scar accounts for about 67% of whole-fruit water loss and can significantly affect fruit quality and postharvest life (Cameron 1982). Based on obtained data (figure 3), decay percentage was

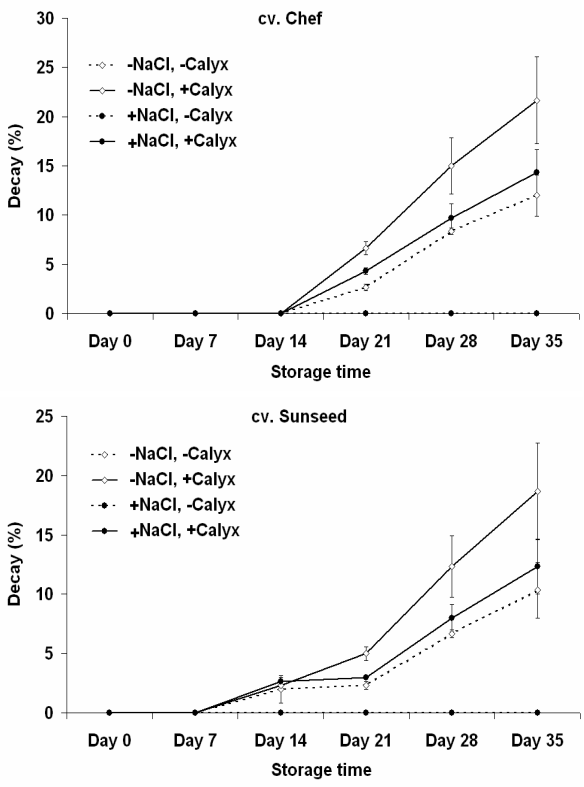

Figure 5. Effect of calyx removal and disinfection with NaCl on fruit decay percent of two tomato cultivars during 35 days storage at 16°C. Vertical error bars on data points represent the ±SE of the mean.

significantly lower in fruits without calyx. In agreement with this, Smid et al. (1996) have shown that 34-70% of bacterial and 62-80% of fungal population was detected in the calyx attached to the tomato fruits. Thus, removal of calyx will lead to decreasing of decay percentage. Our results showed that vitamin C content increased during storage period but minimum increase was recorded in calyx-removed fruits. The substantial increase in vitamin C after calyx removal was also reported for strawberry fruits when peduncle was removed. Removal of fruit peduncle could reduce

the activity of oxidase ascorbic enzyme by lowering the O_2/CO_2 ratio and can cause slower degradation of vitamin C (Janick, 2001).

While a number of factors or treatments affecting ripening rate of tomato fruit have been investigated, there are few reports on the effect of NaCl treatment on fruit ripening rate. The results in the present study showed that NaCl treatment as a surface disinfectant accelerated ripening of tomatoes and reduced decay percentage. Smid et al. (1996) reported that dipping fruit in NaCl reduced both bacterial and fungal population approximately 3-fold than not treated fruit. However, these data are in agreement with the previous suggestion that chlorine disinfection compounds reduced decay percentage (Bartz et al. 2001, Nasrin et al. 2008, Acedo et al. 2009). The preservation mode of NaCl as an antimicrobial agent can be attributed to a number of factors including dehydration, direct effect of chloride ion, removal of oxygen from the medium, sensitization of microorganisms to carbon dioxide, and interference of NaCl with the rapid action of proteolytic enzymes (Cliver 2003).

CONCLUSION

In conclusion, both calyx removal and disinfection with NaCl were effective in reducing decay percentage. Calyx removal delayed ripening by reducing the fruit softening, weight loss, chlorophyll degradation and carotenoid formation whereas disinfection with NaCl accelerated ripening. Therefore, tomatoes can be stored successfully for a longer time at 16ºC and 80% RH if we remove their calyx before storage.

REFERENCES

Acedo, J.R., Chanthasombath, A.L., Sanatem, T., Phomachan, K. and Weinberger, K. (2009): Effect of chlorine on fruit decay and shelf life of 2 tomato cultivars stored at ambient and evaporative cooling condition. Acta Horticulturae 837: 229-236.

Bajracharya, D. (1998): Experiment in plant Physiology: A laboratory manual. New Delhi: Narusa Publishing House.

Bartz, J.A., Eayre, C.G., Mahovic, M.J., Concelmo, D.E., Brecht, J.K. and Sargent, S.A. (2001): Chlorine concentration and the inoculation of tomato fruit in packing house dump tanks. Plant Disease 85: 885-889.

Bustan, A., Cohen, S., Erlich, O., Tsror (Lahkim), L. (2007): Cladosporium species and *Alternaria alternate* cause serious post-harvest early calyx decay in truss tomatoes in Israel. New Disease Reports 15: 62.

Cameron, A.C. (1982): Gas diffusion in bulky plant organs. phD, University of California, Davis.

Cliver, D.O. (2003): Microbial food contamination. In: Viruses and protozoan parasites. (Wilson, C. L. and Droby, S., Eds.), CRC press, Boca Raton, FL.

Diaz-Perez, J.C. (1998): Transpiration rates in Eggplant fruit as affected by fruit and calyx size. Postharvest Biology and Technology 13: 45-49.

FAO. Org. (2009): Statistical database/ faostat/ collections. Production crop.

Hang, J.H. and Gross, K.C. (1998): Surface sterilization of whole tomato fruit with sodium hypochlorite influences subsequent postharvest behavior of fresh – cut slices. Postharvest Biology and Technology 13: 51-58.

Ilic, Z. and Fallik, E. (2007): Stem Scar - Major Pathway for Quality Changes in Tomato Fruit Stored at Different Temperatures. Acta Horticulturae 741: 213-220.

Janick, J. (2001): Horticultural reviews. Journal of the American Society for Horticultural Science 26: 161-238.

Mortazavi, S.M.H. (2006): The physicochemical variation in growth and ripening stages and effect of different conditions of packaging on postharvest quality and storage life of Date. PhD, University of Tarbiat Modares, Tehran, Iran.

Nasrin, T.A.A., Molla, M.M., Alamgir Hossaen, M., Alam, M.S. and Yasmin, L. (2008): Effect of postharvest treatment on shelf life and quality of tomato. Bangladesh Journal of Agricultural Research 33: 579-585.

Paul, V. and Sirvastava, G.C. (2006): Role of surface morphology in determining the ripening behavior of Tomato fruits. Scientia Horticulturae 110: 84-92.

Pila, N., Gol, N.B. and Ramana Rao, T.V. (2010): Effect of post harvest treatment on physicochemical characteristics and shelf life of tomato fruits during storage. American-Eurasian Journal of Agricultural and Environmental Sciences 9: 470-479.

Rahman, M.M., Islam, M.N., Wazed, M.A., Arfin, M.S. and Hossain, M.F.B. (2010): Differentiation of postharvest losses and shelf life of tomato as influenced by different types of polythene at refrigerated condition. International Journal of Sustainable Crop Production 5: 62-65.

Ranaganna, S. (1997): Handbook of analysis and quality control for fruits and vegetables products. 2nd ed. Tata McGrawhill Publishing Company Ltd., New Delhi.

Smid, E.J., Hendriks, L., Boerrigter, H.A.M. and Gorris, L.G.M. (1996): Surface disinfection of tomatoes using the natural plant compound Trans-Cinnamaldehyde. Postharvest Biology and Technology 9: 343-35.

Thompson, A.K. (2003): Fruit and vegetables (Harvesting, Handling and storage). 2nd ed. Wiley Blackwell, UK.

Yang, C.X., Shewfelt, R.L. (1999): Effect of sealing of stem scar on ripening rate and internal ethylene, oxygen and carbon dioxide concentrations of Tomato fruits. Acta Horticulturae 485: 399-404.