African Journal of Biotechnology Vol. 10(32), pp. 6040-6044, 4 July, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.387
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Biologically-based strategies to reduce postharvest losses of tomato

Elsayed F. Abd_Allah[1]*, Abeer Hashem[2] and Asma Al-Huqail[2]

[1]Plant Production Department, Faculty of Food Science and Agriculture, King Saud University, P. O. Box. 2460 Riyadh 11451, Saudi Arabia.
[2]Botany and Microbiology Department, Faculty of Science, King Saud University, P. O. Box. 2460 Riyadh 11451, Saudi Arabia.

Accepted 6 May, 2011

The preharvest employment of *Bacillus subtilis* was highly effective in an augmentation of fruit set and improves general apperance of tomato at harvest. Cooling technology supported the poential of *B. subtilis,* in particularly prevention of postharvest losses of tomato fruits within marketing context. Furthermore, the resultant inhibition of color development and improvement of sensory traits of tomato fruits due to the preharvest application of our formulated *B. subtilis* with the help of cooling technology were indicative of general inhibition of senescence and ripening. This biologically-based strategy deserves further development and application under commercial requirements especially in developing countries like Egypt, where refrigeration is inadequate.

Key words: Biological control, general appearance, *Bacillus subtilis*.

INTRODUCTION

Tomato (*Lycospersicon esculentum* Mill) is one of the most important and widely distributed horticultural vegetable crops in the world as well as Egypt. Tomatoes are major contributors of the carotendiondes (especially lycopene), phenolics and vitamin C in daily diets (Causse et al., 2003). Moreover, results from the epidemiological studies have shown that tomato and its products may have a positive effect against various forms of cancer, especially prostate cancer and cardiovascular diseases (Ellinger et al., 2006). Worldwide postharvest tomato losses are as 30 to 40% (Kader, 1992) and even much higher in some developing countries such as Egypt due to the use of improper handling procedures and lack of methods to prevent decay and senescence (Prigojin et al., 2005). Currently, fungicides are used to control preharvest losses of tomato production (Baider and Cohen, 2003), but the use of prophylactic chemicals in these commodities (tomato fruits) is not allowed in different countries due to oncogenic risks (Unnikrishnan and Nath, 2002).

In Egypt, tomato fruits for the domestic market are not subjects to low temperature storage due to high costs. Consequently, gluts occur during harvest with shortfalls experienced afterwards. Crop grown for export do have low temperature storage facilities but quality and sensory traits of fruit losses still occur. The marketing of organic farming products has markedly expanded because of increased consumer demand for healthy food products, which are free of synthetic chemical residues and the resulting improvements in the production and distribution systems (Sylvander, 1993). However, since organic fruits are not treated with chemical fungicides, they suffer from relatively high rates of decay, which develops during storage and shelflife causing loss in the sensory traits of fruits (Yahia et al., 2004).

In recent years much research has focused on developing alternative non chemical strategies against postharvest diseases trigger softening and dramtic reduction in fruit firmness (Droby et al., 2009; Eshel et al., 2009). In this concept, our formulated *Bacillus subtilis* has been success to plant disease control (Abd_allah et al., 2003), improving the quality and sensory traits of plant yield (Abd_allah, 2005), support plant histology (Abd_allah et al., 2007) and enhancement of plant metabolism towards anabolism (Abd_allah and Ezzat, 2004;

*Corresponding author. E-mail: eabdallah@ksu.edu.sa. Tel: 00966554520360.Fax: 0096614678467.

Abd_allah, 2005; Abd_allah and El-Didomany, 2007). Such success in our formulated biocontrol agent (*B. subtilis*) is still limited due to the production of stable and profitable food should be through combining different non-chemical (biological and physical) control methods (Eshel et al., 2000). Therefore, this study was designed to study the experimentation of formulated *B. subtilis* in concurrence with cooling regarding control postharvest depression in tomato fruit quality to better understanding for the metabolic as well physiological response of tomato fruit.

MATERIALS AND METHODS

Experimental soil and seeds

The study was carried out in greenhouse of tomato production areas in Ismalia, Egypt throughout the growing season of 2007. The soil used throughout this study was a sandy loam with the following properties; organic carbon 0.62; total soluble salts 0.30%, moisture holding capacity 14.8% and pH 7.5. Seeds of tomato (*L. esculentum* Mill var. Brillant) provided with blue seed Co, Nasr City Cairo, Egypt. The seeds were germinated in the main nursery, then transplanted into a greenhouse (528 m^2 with capacity of 1/1200 seedlings). Before the transplantation, the root system of each tomato seedling was dipped in a cell suspension of *B. subtilis* for one hour (Abd_Allah, 1995). The formulation of biocontrol agent, *B. subtiltis* was carried out according to Abd_allah (1995) and used in a rate of 10 g/l chlorine free water (1 g of formulated *B. subtilis* contain 3.6 x 10^9 cfu). Control seedlings (without treatement of formulated *B. subtilis*) were used as reference. Planting (greenhouse) received dropping-irrigation and fertilizers as usual. Formulated *B. subtilis* (10 g/l) were sprinkled on the seedlings (60 L of formulated *B. subtilis* solution/greenhouse) at early morning (one chance/week) periodical until end of the experiment (fruiting stage). During the growing season, light pink tomatoes were picked from each treatment. The formulated *B. subtilis* as well as non-treated control one and then fruit quality was evaluated as viable quality (VQ). Fruit set ratio was calculated as a percentage of fruit number (diameter must be 10 mm) to flower number (including buds just before anthesis).

Storage experiment

Immediately after the harvest, tomato fruits were sorted to eliminate unwanted fruits. The fruits selected to be uniform in size (150± 5 g), light pink color and without any defects. The selected fruits were placed in a double layer in closed cardboard boxes (50 x 30 x 15 cm) with apertures for aeration (Such cardboard boxes are designed for exportation. The boxes were stored either at 20°C for 15 days (Simulation of local marketing) or at 12°C for 10 days plus 5 days at 20°C (Simulation of sea transport and marketing in USA and EU). The storage experiment was carried out in triplicates for each treatment (40 kg, four boxes).

Quality evaluation

General appearance

Visual fruit quality was scored on three point's scale 1 to 3 in which quality is taken as under (1) poor visual appearance; (2) good and acceptable appearance; (3) excellent appearance. A test panel consisting of aroma, colour, firmness, rots development on calyx flesh, defect, dry calyx and dirty tomato fruits.

Eating quality

Assessment of eating quality was conducted on individual tomato fruits using objective measures. Tomato fruits were chosen and homogenized following by centrifugation with 8000 x *g* for 20 min at 5°C. The resulting supernatants were filtered using cheesecloth and then frozen at -20°C until use for analysis.

Firmness

The firmness of tomato fruits was evaluated according to the scale of Kader et al. (1973) with the following accounts: 5, very hard; 4, hard; 3, moderately firm; 2, slightly firm; 1, soft.

Fresh weight loss

Weight loss was determined by weighting tomato fruits at the beginning of the experiment and reweights it again at the end. It was expressed as the loss of initial fresh weight and expressed as the percentage.

Acidity (total titrable acidity)

For each treatment, the supernatant (10 g equivalent) was diluted with 50 ml of distilled water. The solutions were titrated against 0.1 N NaOH (phenolphthalein used as indicator) to end point of pH 8.2 (citric acid used as reference) and acidity expressed as percentage of citric acid (Wills and Ku, 2002).

Total soluble solids

Total soluble solid was evaluated as percent by a hand reractometer using drops of tomato fruits juice that previously extracted.

RESULTS AND DISCUSSION

Currently, the usage of chemical agents remains the major method for choice by far for managing postharvest losses and few postharvest biocontrol products that are commercially available have limited use, mostly in r ich markets (Droby et al., 2009). Biosave (*Pseudomonas syringe* Van Hall) and Shemer (*Metschnikowia fructicola* Kurtzman & Droby) have been registered commercially for postharvest loss control (Kurtzman and Droby, 2001). We found that the preharvest application of our formulated *B. subtilis* was highly effective (significantly) in an augmentation of fruit set of tomato by 24.8% compared with non-treated control one (Table 1). Plant growth regulators such as auxins and gibberellins are known to affect parthenocarby (Chowdhury et al., 2007) and flowering (Khan and Chaudhry, 2006); therefore, synthesized auxins and gibberellins are often too used for promotion of fruit set in some fruity vegetables production including tomato (Sasaki et al., 2005). The production of plant

Table 1. Effect of preharvest treatment of tomato with formulated *B. subtilis* on fruit set (%) and general appearance (GA) of tomato fruits.

Treatment		Fruit set (%)	General appearance (GA)
Non-treated control		69.2	2.35
Formulated *B. subtilis*		92.1	2.74
LSD at:	0.05	12.4	0.27
	0.01	20.3	0.38

Table 2. Effect of preharvest treatment of tomato with formulated *B. subtilis* and storage under different temperatures (°C) on general appearance (GA) of tomato fruits.

Treatment		General appearance (GA) after storage at different temperatures (°C)	
		Storage at 20°C for 15 day (like local marketing)	Storage at 12°C for 10 day + 20°C for 5 day (like transport marketing)
Non-treated control		1.7	2.3
Formulated *B. subtilis*		2.5	3.4
LSD at:	0.05	0.30	0.26
	0.01	0.55	0.47

growth hormones via *B. subtilis* has been demonstrated previously (Arkhipova et al., 2005). Consequently, it has similar suggested mechanism to exogenous application of plant growth hormones. Mechanisms other than production of growth stimulatory by which *B. subtilis* might increase fruit set including production of substance that interacts with the plant's own growth regulatory system and enhancement plant nutrition (Loper and Schroth, 1986). Moreover, the application of *B. subtilis* induced systemic physiological changes in plant metabolism which result in greater improvement towards anabolism (Abd_Allah and Ezzat, 2004; Abd_Allah et al., 2006) and quality of plant yield (Abd_Allah, 2005) via control of plant pathogenic fungi (Abd_Allah, 2007; Abd_Allah et al., 2003); induction of systematic resistance and promotion of endogenous plant hormones such as gibberellins (Kloepper et al., 2004) and enhancement of plant vigor index through stimulate beneficial rhizobacteria in the rhizosphere of host plant, hence, enhance plant nutrition (Abd_Allah and El-Didamony, 2007).

A pre-harvest treatment of *B. subtilis* protects crop fruits against decay and improves its quality (Leibinger et al., 1997). In the same connection, the formulated *B. subtilis* ameliorated the general appearance of tomato fruits (Table 1) compared with non-treated control one. Suppression of plant pathogens (Abd_Allah, 2005) increases the chance to produce healthy, stable and profitable food with minimum defects. Some mechanisms was suggested to be the major role in the biocontrol activity of many antagonists such as nutrient competition (Janisiewicz and Korsten, 2002), direct interaction (Schotsmans et al., 2008), production of cell wall hydrolytic enzymes (Bar-Shimon et al., 2004), induction of systematic resistance (Droby et al., 2002) and production of antimicrobial substances (El-Khallal, 2007). Information on the mechanisms of action for most of the antagonists investigated is still incomplete because of the difficulties associated with the study of complex interactions between a host, a pathogen and an antagonist, as well as other resident microorganisms (Droby et al., 2009). Although, biocontrol has achieved some remarkable success, it is well recognized that at least for the time being, if it is to be part of large-scale agriculture, it should be combined with other control practices (such as cooling), leading integrated pest management (IPM). It was found that cooling was highly effective to control the decrease in general appearance of stored tomato fruits compared with non-cooled one (Table 2). A similar observation was made by Prigojin et al. (2005). Postharvest life functions can not be stopped, but they can be showed down by controlling the storage environment. Low temperatures found to be inhibitor for synthesis of MACC [1-(malonylamino) cyclopropane-1-carboxylic acid) which appear to be the basic process that regulated ACC [1-aminocyclopropane-1-carboxylic acid] hence, ethylene production (Larrigaudière et al., 2009). The reason for such an inhibition in cold remains to be explained, it is probably due to a direct effect of low temperature on ACC synthase activity according to Arrhenius model (Khan and Singh, 2007). In addition, the results have no significant difference between the general appearance of tomato fruits at zero harvest time (Table 1) and those cooled (Table 2), both were in the absence of *B. subtilis* treatment. This underscores the point that postharvest treatment (cooling) cannot improve quality;

Table 3. Effect of preharvest treatment of tomato with formulated *B. subtilis* and storage under different temperatures (℃) on sensory traits of tomato fruits.

Treatment	Storage condition	Sensory traits of tomato fruit				
		Weight loss (%)	Firmness unit	Total soluble sold (%)	Acidity (%)	Color
Non-treated Control	At 20℃ for 15 days (like local marketing)	4.42	3.51	4. 98	1.04	Dark red
	Storage at 12℃ for 10 days + 20℃ for 5 days (like transport marketing)	3.34	4.12	4. 85	o.92	Red
Formulated *B. subtilis*	At 20℃ for 15 days (like local marketing)	2.87	4.08	4. 57	0.81	Light
	Storage at 12℃ for 10 days + 20℃ for 5 days (like transport marketing)	2.40	4.92	4. 28	0.72	Pink
LSD at:	0.05	0.47	0.56	0.25	0.11	
	0.01	0.79	0.75	0.76	0.27	

the best it can improve quality, the best it can hope to do is maintain it, so it must be (especially for export) combing between the biologically and non-chemically based strategies to reduce postharvest losses of tomato.

Our results (Table 2) indicated that the pre-harvest treatment of tomato with formulated *B. subtilis* caused highly significant increase in general appearance of tomato fruits either stored at 20℃ for 15 days (for local marketing) or at 12℃ for 10 days + 20℃ for 5 days (for transport and marketing in USA and EU) by percent of 32.0 and 32.3, respectively. Additionally, we observed that no visable difference in general apperance of tomato fruits stored at cooling system and preharvest treated with *B. subtilis* and stored at non-cooling system. Further suggested mechanism for mode of action of biocontrol agents is eliciting resistance responces in harvested fruits and vegetables (Droby et al., 1993; Wilson et al., 1994). In this context, Abd_Allah et al. (2006) reported that application of formulated *B. subtilis* elicited systemic resistance mechanisms in tomato via lipids metabolism.

Weight loss of tomato fruits was almost related to storage temperature (Znidarcic and Pozel, 2006). Such loss of tomato fruits is usually due to loss of water through transpiration, it can lead to wilting and shrivelling, which reduce both market value and consumer acceptability (Ball, 1997). In regard to this concept, our results (Table 3) showed that fruits stored at 12℃ for 10 days + 20℃ for 5 days (for transport and marketing in USA and EU) lost weight leisurely slower than those stored at 20℃ for 15 days (for local marketing). In general, titrable acidity and total soluble solids of tomato fruits were increased with storge; however, firmness was decreased compared with those at the same picking time (Table 3). A simlar finding has been reported by Znidarcic and Pozel (2006). The resultant inhibition of color development and improvement of sensory traits (firmness, total soluble solides and acidity) of tomato fruits due to the pre-harvest application of formulated *B. subtilis* was indicative of general inhibition of senescence and ripening (Table 3). A similar impression of *B. subtilis* was observed previously in citrus (Obagwu and Korsten, 2003), broccoli (Cui and Harling, 2006) and mango (Vivekananthan et al., 2006).

In conclusion, the quality of tomato fruits could be sustained for about two weeks (15 days) at ambient temperature after preharvest treatment with *B. subtilis*. This biologically-based strateiges deserves further development and application under commercial requirements especially in developing countries like Egypt where refrigeration is inadequate. We have here introduced a new paradigm for biocontrol research that many provide new apportunities for increasing the efficacy and consistency of biocontrol products.

ACKNOWLEDGMENT

Authors wish to thank College of Food and Agricultural Research Center and Deanship of Scientific Research, King Saud University Saudi Arabia for financially supporting this work.

REFERENCES

Abd_Allah EF (1995). Biological Control of Tomato Wilt Disease Caused by *Fusarium oxysporium f.sp. lycopersici*. Ph.D. (Dissertation) in Botany, Faculty of Science, Zagazig University, Egypt.

Abd_Allah EF, Ezzat SM, Sarhan MM, Abd El-Metteleb AA (2003). Biocontrol of peanut southern blight (*Sclerotium rolfsii*) by *Bacillus subtillus*. Egypt. J. Microbiol. 38: 207-216.

Abd_Allah EF, Ezzat SM (2004). Role of lipid metabolism through bioremediation of fusaric acid in germinating peanut seedlings. Phytoparasitica, 32: 38-42.

Abd_Allah EF (2005). Effect of a *Bacillus subtilis* isolate on Southern blight (*Sclerotium rolfsii*) and lipid composition of peanut seeds. Phytoparasitica, 33(5): 460-466.

Abd-Allah, EF, Hashem, Abeer, Ezzat SM (2006). Lipid metabolism in tomato and bean as a sensitive monitor for biocontrol of wilt diseases. Phytoparasitica, 34: 516-522.

Abd_Allah, EF (2007). Biological control of *Rhizoctonia solani* in *Phaseolus vulgaris* by *Bacillus subtillus*. Egypt. J. Microbiol. 42: 21-28.

Abd-Allah EF, El-Didamony G (2007). Effect of seed treatment of *Arachis hypogaea* with *Bacillus subtilis* on nodulation in biocontrol of southern Blight (*Sclerotium rolfsii*) disease. Phytoparasitica, 35(1): 8-12.

Abd_Allah EF, Ezzat SM, Tohamy MR (2007). *Bacillus subtilis* as an alternative biologically based strategy for controlling Fusarium wilt disease in tomato: A histological study. Phytoparasitica, 35(5): 474-478.

Arkhipova TN, Veselov SU, Melentiev AI, Martynenko EV, Kudoyarova GR (2005). Ability of bacterium *Bacillus subtilis* to produce cytokinins and to influence the growth and endogenous hormone content of lettuce plants. Plant Soil, 272: 201-209.

Baider A, Cohen Y (2003). Synergistic interaction between BABA and mancozeb in controlling *Phytophthora infestans* in potato and tomato and *Pseudoperonospora cubensis* in cucumber. Phytoparasitica, 31: 399-409.

Bar-Shimon M, Yehuda H, Cohen L, Weiss B, Kobeshnikov A, Daus A, Goldway M, Wisniewski M, Droby S (2004). Characterization of extracellular lytic enzymes produced by the yeast biocontrol agent *Candida oleophila*. Curr. Genet., 45: 140-148.

Ball JA (1997). Evaluation of two lipid-based edible coatings for their ability to preserve postharvest quality of green ball peppers. M.Sc. Thesis, Blacksburg, Virginia, p. 89.

Causse M, Buret M, Robini K, Verschave P (2003). Inheritance of nutritional and sensory quality traits in fresh market tomato and relation to consumer preferences. J. Food Sci. 68: 2342-2350.

Chowdhury RN, Rasul MG, Islam AKMA, Mian MAK, Ahmed JU (2007). Effect of Plant Growth Regulators for Induction of Parthenocarpic Fruit in Kakrol (*Momordica dioica* Roxb.). Bangladesh J. Plant Breed. Genet. 20(2): 17-22.

Cui X, Harling R (2006). Evaluation of bacterial antagonists for biological control of broccoli head rot caused by *Pseudomonas fluorescens*. Phytopathology, 96:408-416.

Droby S, Hofstein R, Wilson CL, Wisniewski M, Fridlender B, Cohen L, Weiss B, Daus A, Timar D, Chalutz E (1993). Pilot testing of Pichia guilliermondii: a biocontrol agent of postharvest diseases of citrus fruit. Biological Control, 3: 47-52.

Droby S, Vinokur V, Weiss B, Cohen L, Daus A, Goldschmidt EE, Porat R (2002). Induction of resistance to *Penicillium digitatum* in grapefruit by the yeast biocontrol agent *Candida oleophila*. Photopathology, 92: 393-399.

Droby S, Wisniewski M, Macarisin D, Wilson C (2009). Twenty years of postharvest biocontrol research: It is time for a new paradigm. Postharvest Biol. Technol. 52: 137-145.

El-Khallal Samia M (2007). Induction and modulation of resistance in tomato plants against *Fusarium* wilt disease by bioagent fungi (arbuscular mycorrhiza) and/or hormonal elicitors (Jasmonic acid & Salicylic acid): 2-Changes in the antioxidant enzymes, phenolic compounds and pathogen related- proteins. Aust. J. Basic Appl. Sci. 1(4): 717-732.

Ellinger S, Ellinger J, Stehle P (2006). Tomatoes, tomato products and lycopene in the prevention and treatment of prostate cancer: do we have the evidence from intervention studies?". Curr. Opin. Clin. Nutr. Metab. Care, 9(6): 722-727.

Eshel D, Gamliel A, Grinstein A, Di Primo P, Katan J (2000). Combined soil treatments and sequence of application in improving the control of soilborne pathogens. Phytopathology, 90: 751-757.

Eshel D, Regev R, Orenstein J, Droby S, Gan-Mor S (2009). Combining physical, chemical and biological methods for synergistic control of postharvest diseases: A case study of Black Root Rot of carrot. Postharvest Biol. Technol. 54: 48-52.

Janisiewicz W, Korsten L (2002). Biological control of postharvest diseases of fruits. Annu. Rev. Phytopathol. 40: 411-441.

Kader A, Morris LL, Lipton WJ (1973). Systems for scoring quality of harvested lettuce. Hort. Sci. 8: 408-409.

Kader AA (1992). Postharvest Technology of Horticultural Crops. University of California, Publication, 3311.

Khan AS, Chaudhry NY (2006). Auxins partially restores the cambial activity in heavy metals treated plants. *Luffa cylindrica* L. (Cucurbitaceae) under mercury stress. J. Food Agric. Environ. 4: 276-281.

Khan AS, Singh Z (2007). Methyl jasmonate promtes fruit ripening and improves fruit quality in Japanese plum. J. Hortic. Sci. Biotechnol. 82: 695-706.

Kloepper JW, Ryu CM, Zhang S (2004). Induced systemic resistance and promotion of plant growth by *Bacillus* spp. Phytopathology, 94: 1259-1266.

Kurtzman CP, Droby S (2001). Metschnikowia fructicola, a new ascosporic yeast with potential for biocontrol of postharvest fruit rots. Syst. Appl. Microbiol. 24: 395-399.

Larrigaudière C, Candan AP, Ubach D, Graell J (2009). Physiological response of ‘Larry Ann’ plums to cold storage and 1-MCP treatment. Postharvest Biol. Technol. 51: 56-61.

Leibinger W, Breuker B, Hahn M, Mendgen K (1997.) Control of postharvest pathogens and colonization of the apple surface by antagonistic microorganisms in the field. Phytopathology, 87: 1103-1110.

Loper JE, Schroth MN (1986). Influence of bacterial sources of indole-3-acetic acid on root elongation of sugar beet. Phytopathology, 76:386-389.

Obagwu J, Korsten L (2003). Integrated control of citrus green and blue molds using *Bacillus subtilis* in combination with sodium bicarbonate or hot water. Postharvest Biol. Technol. 28: 187-194.

Prigojin I, Fallik E, Qat Y, Ajalin I, Allam H, Ezzat M, Al-Masri M, Bader M (2005). Middle East regional agricultural program: Survey on postharvest losses of tomato fruit (Lycopersicon esculentum) and table grapes (*Vitis vinifera*). Proceedings of the 5th international postharvest symposium, June 6-11 in Verona, Italy. Acta horticulturae (ISHS), 682: 1049-1056.

Sasaki H, Yano T, Yamasaki A (2005). Reduction of high temperature inhibition in tomato fruit set by plant growth regulators. Jan. Agric. Res. Quarterly, 39: 135-138.

Schotsmans WC, Braun G, DeLong JM, Prange RK (2008). Temperature and controlled atmosphere effects on efficacy of *Muscodor albus* as a biofumigant. Biological control, 4: 101-110.

Sylvander B (1993). Conventions on quality in the fruit and vegetables sector: Results on the organic sector. Acta Horticulturae, p. 340.

Unnikrishnan V, Nath BS (2002). Hazardous chemicals in foods. Ind. J. Dairy Biosci. 11: 155-158.

Vivekananthan R, Ravi M, Ramnathan A, Kumar E, Samiyappan R (2006). Pre-harvest application of a new biocontrol formulation induces resistance to post-harvest anthracnose and enhances fruit yield in mango. Phytopathol. Mediterr. 45: 126-138.

Wills RBH, Ku VVV (2002). The use of 1-MCP to extend the time to ripen of green tomatoes and postharvest life of ripe tomatoes. Postharvest Biology and Technology 26: 85-90.

Wilson CL, El Ghauoth A, Chalutz E, Droby S, Stevens C, Lu JY, Khan VA, Arul J (1994). Potential of induced resistance to control postharvest diseases of fruits and vegetables. Plant Dis. 78: 837-844.

Yahia EM, Barry-Ryan C, Dris R (2004). Treatments and Techniques to Minimise the Postharvest Losses of Perishable Food Crops. *In* Production Practices and Quality Assessment of Food Crops, Ramdane Dris and Shri Mohan Jain [Eds]. pp. 95-133.

Znidarcic D, Pozrl T (2006). Comparative study of quality changes in tomato cv. Malike (*Lycopersicon esculentum* Mill.) whilst stored at different temperatures. Acta Agriculturae Slovenica, 87(2): 235-243.