EFFECT OF DISINFECTION SOLUTION DIOX FORTE (CHLORINE DIOXIDE - CLO_2) ON PROLONGING SHELFLIFE OF GRAPES AND TOMATOES

Cao Dinh Dung[a*], Nguyen Xuan Hieu[a], Truong Van Duc[a], Le Dung[b], Ha Bich Ngoc[b], Peter De Steur[c], Le Ngoc Lan[d], Nguyen Thuy Quy Tu[e]

[a]*Potato, Vegetable and Flower Research Center, Institute of Agricultural Science for Sounthern Vietnam, Ho Chi Minh City, Vietnam*
[b]*The Faculty of Agriculture and Forestry, Dalat University, Lamdong, Vietnam*
[c]*East Flanders province, Belgium*
[d]*Vietnam Academy of Agricultural Sciences, Hanoi, Vietnam*
[e]*Lamdong Agricultural and Rural Development Department, Lamdong, Vietnam*

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Abstract

This paper reports a study of the effect of disinfection solution Diox Forte (chlorine dioxide - ClO_2) at 0, 10, 20, 40, 80 and 160 ppm on the shelflife of grapes and tomatoes at room temperature and cold store (5°C). The shelflives of grapes and tomatoes were significantly increased when treated with Diox Forte at 40 ppm for grapes and 10 – 20 ppm for tomatoes. The shelflife of grapes treated with Diox Forte at 40 ppm at room temperature and cold store (5°C) was increased for up to 17 days and 22 days, respectively. Meanwhile, the shelflife of tomato cultivars 'Rista' and 'Triatlon'treated with Diox Forte at 40 ppm was significantly increased by 45 days and 29 days, respectively, compared to those of untreated tomatoes; the shelflife of cultivar 'Octavio' treated with Diox Forte at 10 ppm reached a maximum at 46 days, compared to untreated tomatoes; and cultivar 'Olivade' did not response to Diox Forte solutions. In the absence of Diox Forte, the shelflife of cultivar 'Octavio' was the highest with 40 days, followed by 'Olivade' (31 days) and 'Triatlon' (25 days) as compared to cultivar 'Rista' (24 days).

Keywords: ClO2; Cold storage; Diox Forte; Grapes; Room temperature; Tomatoes.

1. INTRODUCTION

Fruits and vegetables play an important role in human nutrition, particularly as a source of vitamins, minerals, dietary fibre, and antioxidants (Kader & Rolle, 2004). Abundant consumption of fruits and vegetables and low intake of red meat in diet play an essential role in the causation and prevention of cancers, cardiovascular diseases, alzheimer, cataracts and some of the functional declines linked with aging (Willet, 1995; Liu, 2003). Approximately one-third of the edible parts of food produced for

*Corresponding author: Email: caodinhdung2003@yahoo.com

human consumption gets lost or wasted globally, which is about 1.3 billion tons per year (Gustavsson, Cederberg, Sonesson, van Otterdijk & Meybeck, 2011). Fresh fruits and vegetables account for nearly 44% of consumer and food service losses due to product deterioration, excess perishable products that are discarded and postharvest losses in developing countries vary greatly from 1 to 50% or even higher (Lipinski et al., 2013; Kader, 2005). Roughly one-third of horticultural crops produced are never consumed by humans (Kader & Rolle, 2004). Thus, the reduction of postharvest losses can increase food availability to the growing population of this world, decrease the area needed for production, and conserve natural resources (Kader & Rolle, 2004). Also, minimising postharvest losses in quality will ensure the availability of fresh produce to the domestic and international consumers consequently will promote international trade.

Chlorine dioxide (ClO_2) is used as a bleaching agent at paper manufacturing plants, and in public water treatment facilities to make drinking water safer. In 2001, ClO_2 and chlorite are used to decontaminate a number of public buildings following the release of anthrax spores in the United States (ATSDR, para. 4) and for water disinfection at Belgium (Tzanavaras et al., 2007). Chlorine dioxide (ClO_2) gas is used to prevent the development of bacteria on fruits and vegetables (Han et al., 2000). However, ClO_2 gas cannot be compressed and stored under the pressure due to the explosion. Therefore, it is impossible to ship and consequently it is difficult to apply to postharvest sector of fruits and vegetables (Lee et al., 2004; Sy et al., 2005). Solutions containing ClO_2 are commonly used in fruit and vegetable postharvest to improve their shelf lives (Beuchat, 1998; Gómez-López, 2009). Cell membrane has been identified as the primary target of ClO_2 on microbial cells in *Escherichia coli* (Bernarde et al., 1967). ClO_2 then affect on protein synthesis and controlled the permeability of bacteria (Berg et al., 1986). Study of the effect of ClO_2 on *Bacillus subtilis* bacteria indicates that *Bacillus subtilis* spores can be damaged and die in the presence of ClO_2 (Young & Setlow, 2003; Peta et al., 2003). ClO_2 reacts with RNA of bacteria, although in bacterial and fungal cells might not be the primary factor (Alvarez & O'Brien, 1982). ClO_2 is effective in reducing the numbers of harmful bacteria on fruits and vegetables (Table 1).

Disinfection solution Diox Forte is developed by Aquaecologic company– Belgium by using ClO_2. Solution Diox Forte is used as water disinfection solution that reduces the harmful microorganism population on fruits and vegetables and consequently shelf lives of fruits and vegetables were increased. Diox Forte is commonly used in Belgium and other Eroupean countries because ClO2 is more powered than chlorine in killing harmful microorganisms and safe for human health (Aquaecologic, para.2).

Table 1. Effect of ClO_2 on reducing numbers of harmful bacteria on several fruits and vegetables

Products	Microorganisms	ClO_2 (mg/L)	Time (minute)	Log reduction	References
Lettuces	Listeria monocytogenes	5	10	8	Zhang and Farber (1996)
Sweet peppers	Listeria monocytogenes	5	10	8	Zhang and Farber (1996)
Cabbages	L. monocytogenes	3	10	37	Han et al. (2001)
Lettuces	Escherichia coli O157:H7	10	5	12	Singh et al. (2002a)
Lettuces	E. coli O157:H7	20	15	17	Singh et al. (2002b)
Baby carrots	E. coli O157:H7	20	15	25	Singh et al. (2002b)
Apples	Enterobacter sakazakii	100	1	≥ 49.9	Kim et al. (2006)
Tomatoes				≥ 35.9	
Lettuces				≥ 40.5	
Apples	Salmonella	5	10	≈ 20	Huang et al. (2006)
	E. coli O157:H7			≈ 10	
	Salmonella			≈ 10	
Tomatoes	Salmonella enterica	20	1	50	Pao et al. (2007)
	Erwinia carotovora	10	1	50	
Mungbean sprouts	Salmonella typhimurium	100	5	30	Jin and Lee (2007)
	L. monocytogenes			15	
Blueberries	L. monocytogenes	15	120	48.8	Wu and Kim (2007)
	Pseudomonas aeruginosa		120	44.8	
	S. typhimurium		20	32.2	
	Staphylococcus aureus		30	45.6	
	Yersinia enterocolitica		60	36.9	

Grapes (*Vitis vinifera*) contain several polyphenols including quercetin, resveratrol, catechins, anthocyanins, and proanthocyanidins (Cantos et al., 2002; Xu et al., 2011). Grapes and polyphenols have been linked epidemiologically to improved bone health. In Australian men, red wine consumption was positively associated with change in lumbar spine bone mineral density over 2 years (Yin et al., 2011). In women aged 18–79, total flavonoid, anthocyanin, flavonol, and flavonoid polymer intakes were positively associated with spine bone mineral (Welch et al., 2012). In Vietnam, grapes are grown at Ninhthuan province because of its dry and hot temperature.

Tomatoes (*Solanum lycopersicum*) are high nutrition crops. Tomatoes supply more than 80% of lycopene for users in America. Tomatoes can help reducing cardiovascular diseases (Clinton, 1998). Sesso et al. (2003) stated that middle aged people using tomatoes with 7 – 10 kg/week reduced cardiovascular disease risk by 29 – 32% as compared to people using 1.5 kg/week. Tomatoes are cultivated along Vietnam. In Dalat city, Lamdong province, tomatoes are grown all year round thanks to its favourable climate conditions. Tomato cultivated varieties are mainly imported from other countries. Rista is a commonly cultivars in Dalat city. In 2016, under the cooperation between East Flanders province, Belgium and Potato, Vegetable and Flower Research Center, Belgium cultivars of Triatlon, Octavio and Olivade (Figure 1 and Table 2) were screened in Dalat city, Lamdong province.

(a) (b) (c) (d)

Figure 1. Tomato cultivars used in the study

Note: (a) Triatlon; (b) Olivade; (c) Octavio; (d) Rista

Grapes and tomatoes are easily damaged by harmful microorganisms. Therefore, the effect of disinfection solution Diox Forte on the shelflives of grapes and tomatoes was studied. The aim of the study was to (1) determine the suitable rate of Diox Forte in prolonging shelflives of grapes and tomatoes and (2) compare the shelflives between tomato cultivars.

Table 2. Agronomic characters of tomato cultivars used in this study

Cultivars	Fruit's height (cm)	Fruit's diameter (cm)	Numbers of locular cavities
Rista	6.33a	5.83b	4
Olivade	6.33a	5.73bc	4
Octavio	4.93de	6.30a	3
Triatlon	4.73e	5.93ab	2
Prob.	*	*	

Note: Numbers in the same column followed by the same low case letter(s) were not significantly different at $p < 0.05$ by Duncan's Multiple Range Test

2. MATERIALS AND METHODS

2.1. Materials

Grape cultivar '*Do Ba Moi*' was purchased at Big C supermarket in Dalat. All fruits with the same mature stage were selected. Tomatoes were harvested in the field trial at Potato, Vegetable and Flower Research Center. Tomato fruits were harvested at the third fruit sets with the same mature stage (70% area of skin having red colour). Cultivars '*Rista*' originated from Holland and cultivars '*Triatlon*', '*Octavio*' and '*Olivade*' originated from Belgium. Cultivation protocol was applied by the Research Center's protocol. Healthy fruits of grapes and tomatoes were selected and fruits were randomly chosen for trials at the laboratory.

2.2. Methods

2.2.1. Experiment 1: Effect of disinfection solution Diox Forte at different rates on the shelflife of grapes stored at room temperature

The experiment was arranged in a completely randomized design, with 6 treatments, 7 replications, 10 fruits per replication. Diox Forte was prepared at 0, 10, 20, 40, 80 and 160 ppm. Grapes were gently washed in Diox Forte at the above rates in 2 minutes and then were placed on tissue paper to dry the fruit surface. All treatments were then placed at postharvest room to assess their shelflives.

2.2.2. Experiment 2: Effect of disinfection solution Diox Forte at different rates on the shelflife of grapes stored at 5^{o}C

The experiment was arranged in a completely randomized design, with 6 treatments, 7 replications, 10 fruits per replication. Diox Forte was prepared at 0, 10, 20, 40, 80 and 160 ppm. Grapes were gently washed in Diox Forte at the above rates in 2 minutes and then were placed on tissue paper to dry the fruit surface. All treatments were then placed in cold store at 5^{o}C to assess the shelflives.

2.2.3. Experiment 3: Effect of disinfection solution Diox Forte at different rates on the shelflife of the different tomatoes cultivars stored at room temperature

A factorial experiment was arranged in a completely randomized design, with 7 replications, 10 fruits per replication.

Factor of Diox Forte rate: Solution of Diox Forte was prepared at 0, 10, 20, 40 ppm.

Factor of tomato cultivars*:* Cultivars of *'Rista'*, *'Triatlon'*, *'Octavio'* and '*Olivade'*. Tomatoes were gently washed in Diox Forte at the above rates in 2 minutes and then were placed on tissue paper to dry the fruit surface. All treatments were then placed at postharvest room to assess their shelflives. Except for experiment placing in cold store, other experiments were placed in postharvest room at day/night temperature: 23±3^{o}C/16±2^{o}C, 60±10% RH with a 12h photoperiod. The light flux densities are 8 µm/m/s.

Measurements**:**

- *Shelflife of grapes (days)***:** Shelflife of grapes was determined when more than 50% of fruits (6/10 pieces) were damaged.

- *Shelflife of tomatoes (days)***:** Shelflife of tomatoes was determined when more than 50% of fruits (6/10 pieces) were damaged or very soft.

Diox Forte solution preparation: Solution Diox Forte was provided by Aquaecologic company, Belgium. Diox Forte solution was prepared by mixing 750 ml solution Diox Forte 0,75% A to 250 ml solution Diox Forte 0,75% B to make 1L Diox Forte solution with 7.500 mg/L ClO2. This stock solution was kept at normal room for 24 h and then was diluted to 10, 20, 40, 80 and 160 ppm for each treatment.

2.3. Statistical analysis of data

Shelflives of grapes and tomatoes from treatments effect were analyzed by 1-way and 2-way ANOVA using the statistical package SAS 9.1. Treatment means were compared by LSD at $P < 0.05$ and standard errors of the mean (± SE) were shown as appropriate. Where possible, mean comparisons were made using Duncan's Multiple Range Test. All the assumptions of ANOVA were checked to ensure the validity of the statistical analysis.

3. RESULTS AND DISCUSSION

3.1. Effect of disinfection solution Diox Forte at different rates on the shelflife of grapes at room temperature

Shelflife of fruits, vegetables and flowers are affected by many factors, such as accumulated carbohydrates rate, exogenous and endogenous ethylene, microorganisms, postharvest environment and physiological changes of themselves (Dung et al., 2013). Microorganisms reduce the shelf lives and quality of fruits. Microorganism disinfection solution such as ClO_2 decreases harmful microorganism population on fruits and therefore shelflives of fruits significantly increase (Beuchat, 1998; Gómez-López, 2009). Microorganism population on tomato reduced from 35. 9 – 50 times when treated with ClO_2 at 10 – 100 mg/L in 1 minute as compared to those without treating with ClO2 (Kim et al., 2006; Pao et al., 2007). Shelflife of grapes increased with the use of Diox Forte (clorine dioxide – ClO_2) and reached a maximum (17 days) with Diox Forte at 40 ppm. Shelflife of grapes treated with Diox Forte at 40 ppm was significantly ($p < 0.05$) higher by 69% than that of control. Continuing increasing Diox Forte rate to 80 or 160 ppm, shelflife of grapes decreased to 12 days (Figure 2).

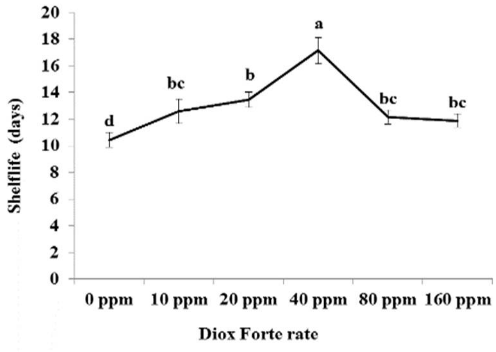

Figure 2. Effect of Diox Forte at different rates on the shelflife of grapes stored at room temperature

Note: Values followed by the same low case letter(s) were not significantly different at $p < 0.05$ by Ducan's Multiple Range Test. Standard error (± SE) of means were shown as appropriate

The decrease in shelflife of grapes with higher Diox Fort rate could be caused by the toxic effect. Studying on the effect of 8–hydroxyquinoline sulphate (8HQS) on vaselife of waxflowers showed that 8HQS at high rate caused a toxic effect on leaves and flowers by causing an injury and consequently reduced vaselife of flowers and leaves (Dung et al., 2013).

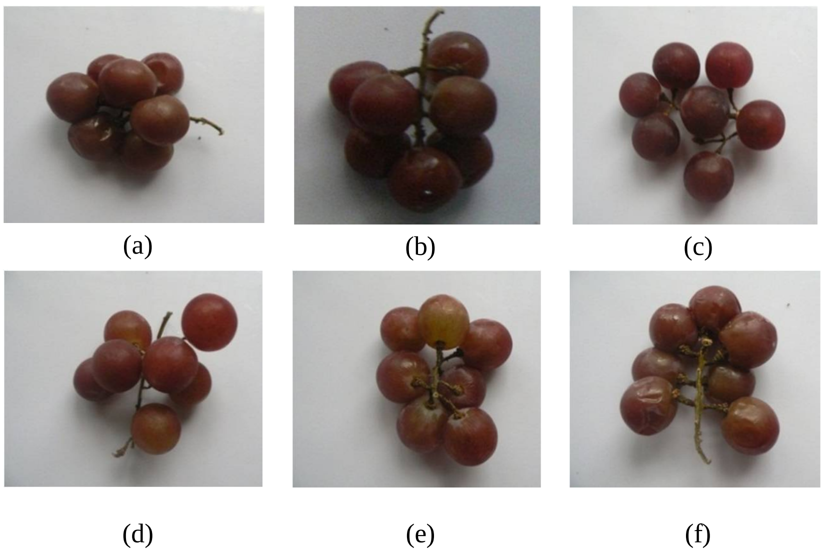

Figure 3. Grapes after 8-day treating with Diox Forte at room temperature

Note: (a) 0 ppm; (b) 10 ppm; (c) 20 ppm; (d) 40 ppm; (e) 80 ppm; (f)160 ppm

3.2. Effect of disinfection solution Diox Forte at different rates on the shelflife of grapes stored at 5^{o}C

Cold store is a common method to increase the shelflife and quality of fruits, vegetables and flowers. Cold store reduces the respiration, transpiration, ethylene production and the development of harmful microorganisms (Reid & Seaton, 2001). Zhao (2013) stated that bacteria causing fruits and vegetables rot *Erwinia carotovora sub sp. carotovora* notably increased at 25^{o}C. The combination between cold store and disinfection Diox Forte significantly increased the shelflife of grapes (Figures 2 and 4). The Shelflife of grapes reached maximal length (22 days) when treated with Diox Forte at 40 ppm. At this rate, the shelflife of grapes significantly ($p < 0.05$) greater by 103% as compared to that without using Diox Forte and higher than those of treatments with other rates of Diox Forte. The shelflife of grapes was 11, 14, 14, 12 and 11 days when treated with Diox Forte at 0, 10, 20, 80 and 160 ppm respectively (Figure 4).

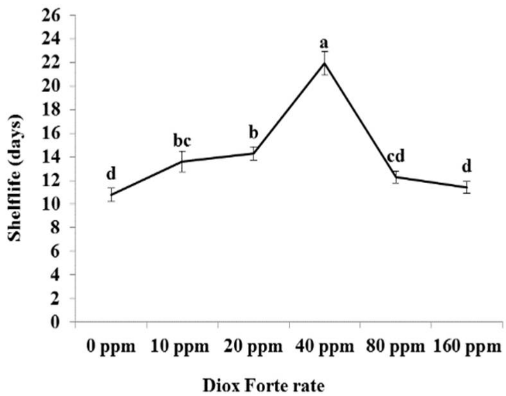

Figure 4. Effect of Diox Forte at different rates on the shelflife of grapes stored at 5^{o}C

Note: Values followed by the same low case letter(s) were not significantly different at $p < 0.05$ by Ducan’s Multiple Range Test. Standard error (± SE) of means were shown as appropriate

3.3. Effect of disinfection solution Diox Forte at different rates on the shelflife of tomatoes stored at room temperature

The averaged shelflife of tomatoes treated with Diox Forte was significantly ($p < 0.05$) higher than that of untreated tomatoes. Diox Forte was more effective in prolonging shelflife of cultivars of ‘*Octavio*’ and ‘*Rista*’, but not in cultivars of ‘*Triatlon*’ and ‘*Olivade*’ (Table 3). While the response of different cultivars to the same solution was different, the response of each cultivar to the different solutions was different. Dung et al. (2016) stated that vase life of waxflowers was different to vase solutions, depending on genetic. With the presence of Diox Forte, the shelflife of cultivar ‘*Rista*’ (24 days) was significantly ($p < 0.05$) lower than that of cultivar ‘*Octavio*’ (40 days) or ‘*Olivade*’ (31 days). While the shelflife of cultivar ‘*Triatlon*’ (25 days) was similar to this of cultivar '*Rista*', the shelflife of cultivars of '*Octavio*' and '*Olivade*' were 46 and 32 days, respectively when treated with Diox Forte at 10 ppm. Increasing Diox Forte rates to 20 or 40 ppm would decrease the shelflife of these cultivars.

Alternatively, the shelflives of cultivars of '*Rista*' and '*Triatlon*' treated with Diox Forte were 45 and 29 days, respectively at 20 ppm and or 40 ppm (Table 3).

Table 3. Effect of disinfection solution Diox Forte at different rates on the shelflife of different tomato cultivars

Diox Forte	Cultivars				Averaged shelflife of cultivars factor
	Rista	Triatlon	Octavio	Olivade	
0 ppm	24.0 g	25.0 gf	40.0 b	31.0 cd	30.0 B
10 ppm	27.0 ef	27.7 e	46.0 a	32.0 c	33.2 A
20 ppm	45.0 a	29.0 de	29.0 de	31.0 cd	33.5 A
40 ppm	45.0 a	29.0 de	29.0 de	29.0 de	33.0 A
Averaged shelflife of Diox Forte factor	35.3A	27.7 C	36.0 A	30.8 B	

Note: Means in the same column or row followed by the same upper letter(s) were not significantly different at $p < 0.05$ by Ducan's Multiple Range Test. Means in the same column followed by the same low case letter(s) were not significantly different at $p < 0.05$ by Ducan's Multiple Range Test.

4. CONCLUSION

Disinfection solution Diox Forte was effective in prolonging shelflives of grapes and tomatoes. Disinfection solution Diox Forte with 40 ppm was the most effective rate to improve the shelflife of grapes stored at room temperature or cold store (5^{o}C).

While the disinfection solution Diox Forte with 40 ppm was the most suitable for improving shelflife of tomato cultivar '*Octavio*', that with 20 ppm was the most suitable for improving shelflife of cultivar '*Rista*' and '*Triatlon*'. However, the shelflife of cultivar '*Olivade*' did not changed with Diox Forte.

The shelflife of different tomato cultivars was differently. While the cultivar of '*Octavio*' had the highest shelflife, followed by cultivar '*Olivade*', the cultivars of '*Rista'* and '*Triatlon*' were similar to each other.

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ẢNH HƯỞNG CỦA DUNG DỊCH DIỆT KHUẨN DIOX FORTE (CHLORINE DIOXIDE - CLO_2) ĐẾN KHẢ NĂNG KÉO DÀI TUỔI THỌ CỦA NHO VÀ CÀ CHUA

Cao Đình Dũng[a*], Nguyễn Xuân Hiểu[a], Trương Văn Đức[a], Lê Dũng[b], Hà Bích Ngọc[b], Peter De Steur[c], Lê Ngọc Lan[d], Nguyễn Thùy Qúy Tú[e]

[a]*Trung tâm Nghiên cứu Khoai tây, Rau và Hoa, Viện Khoa học Kỹ thuật Nông nghiệp Miền nam, TP. Hồ Chí Minh, Việt Nam*
[b]*Khoa Nông Lâm, Trường Đại học Đà Lạt, Lâm Đồng, Việt Nam*
[c]*Tỉnh Đông Flanders, Vương quốc Bỉ*
[d]*Viện Khoa học Nông nghiệp Việt Nam, Hà Nội, Việt Nam*
[e]*Sở Nông nghiệp và Phát triển Nông thôn tỉnh Lâm Đồng, Lâm Đồng, Việt Nam*
[*]*Tác giả liên hệ: Email: caodinhdung2003@yahoo.com*

Lịch sử bài báo
Nhận ngày 14 tháng 05 năm 2016
Chỉnh sửa lần 01 ngày 22 tháng 07 năm 2016 | Chỉnh sửa lần 02 ngày 09 tháng 08 năm 2016
Chấp nhận đăng ngày 28 tháng 08 năm 2016

Tóm tắt

Ảnh hưởng của dung dịch diệt khuẩn Diox Forte (chlorine dioxide - CLO_2) ở ồng độ 0, 10, 20, 40, 80 và 160 ppm lên tuổi thọ của nho và cà chua trong điều kiện nhiệt độ phòng và nhiệt độ lạnh 5°C được tiến hành nghiên cứu. Tuổi thọ của nho và cà chua tăng một cách có ý nghĩa khi sử dụng dung dịch Diox Forte ở nồng độ 40 ppm cho nho và 10 – 20 ppm cho cà chua. Tuổi thọ của nho tăng thêm 64% (17 ngày) và 103% (22 ngày) khi sử lý với Diox Forte ở nồng độ 40 ppm và bảo quản trong điều kiện nhiệt độ phòng và trong bảo quản lạnh ở nhiệt độ 5°C, theo thứ tự tương ứng. Tuổi thọ giống cà chua Rista (45 ngày) và Triatlon (29 ngày) đạt cực đại với Diox Forte nồng độ 40 ppm và cao hơn 87,5% và 16% so với khi không xử lý Diox Forte, theo thứ tự tương ứng. Trong khi đó tuổi thọ giống Octavio (46 ngày) đạt cực đại với Diox Forte nồng độ 10 ppm và cao hơn 6 ngày so với không xử lý. Trái lại thì tuổi thọ giống Olivade hầu như không không tăng đáng kể khi sử dụng Diox Forte. Trong số các giống cà chua khảo sát thì giống Octavio có tuổi thọ lớn nhất (40 ngày), theo sau là giống Olivade (31 ngày) và Triatlon (25 ngày). Giống Rista có tuổi thọ nhỏ nhất (24 ngày) so với các giống khác khi không dùng dung dịch diệt diệt khuẩn Diox Forte.

Từ khóa: Cà chua; CLO_2; Diox Forte; Nhiệt độ lạnh; Nhiệt độ phòng; Nho.