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RESEARCH ARTICLE

Influence of fluctuating environmental factors on phytochemical changes in eggplant and cucumber during postharvest storage

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ABSTRACT

In tropical countries, fresh vegetables travelling from "farm-to-fork" are continuously exposed to different temperatures and solar radiation levels that seriously affect their phytochemical composition and consequently, their overall postharvest quality. Phytochemicals in plants are known for their valuable antioxidants and potential anti-inflammatory, and anti-cancer benefits. In this work, freshly harvested eggplants and cucumbers were stored for 10 days in controlled chambers with varied combinations of temperature and light. Crude extracts of freeze-dried produce were used to determine the total phenolic contents (TPC) using the Folin-Ciocalteau method, then these reactions were monitored spectrophotometrically. Phytochemical changes were quantified over time using kinetic models. . Exposing vegetables to elevated temperatures (30oC) and direct light was found to significantly degrade their TPC. However, a rise in TPC ($P < 0.05$) was observed when the crops were maintained at 10oC in the absence of light. Moreover, storage at fluctuating environmental conditions was found to be the main contributor of the phenolic degradation in fresh eggplant (49.7% loss) and cucumber (83.8% loss). This study was useful in advancing knowledge on characterizing postharvest quality loss of fresh commodities from the perspective of health attributes rather than conventional sensory parameters, and aiming to effectively quantify postharvest losses in a more holistic manner.

Keywords: Phytochemicals, eggplant, cucumber, postharvest storage, environmental factors

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INTRODUCTION

Fruits and vegetables play important roles in human diets and health. The World Health Organization estimated that low fruit and vegetable intake contributed to 1.7 million deaths worldwide annually (WHO, 2012). Food insecurity in many countries has taken the form of chronic non-communicable diseases (NCDs): including cancer, heart problems and diabetes. Consequently, there has been a global awareness of the beneficial effects of consuming fresh fruits and vegetables in order to alleviate the risk of those diseases. Various studies have shown strong evidence of the protective effects of plant foods against cancer and cardiovascular illness. Therefore, these foods are recognized for their health-promoting effects beside their nutritional contributions (Alarcón-Flores et al., 2014; Kaur et al., 2014; Mukherjee et al., 2013). Fruits and vegetables are rich in phytochemicals or phytonutrients, which act as

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antioxidants when consumed due to their ability to scavenge free oxygen radicals released in the human body under oxidative stress and thus protect cell membranes from oxidative damage (Tiwari et al., 2013).

Many researchers have proved the existence of an extensive range of phytochemicals in fruits and vegetables (Boivin et al., 2009). These phytochemicals are typically grouped according to function, chemical structure and also on source. Phytochemicals in fresh commodities are mainly ascorbic acid, carotenoids and phenolic/polyphenol compounds (Xu et al., 2009). Among the vegetables, eggplant (*Solanum melongena* L.) and cucumber (*Cucumis sativus* L.) provide a wide variety of health benefits including valuable antioxidant, anti-inflammatory, and anti-cancer benefits due to their high content of antioxidant nutrients (Mukherjee et al., 2013; Okmen et al., 2009). They are best grown in tropical and sub-tropical areas (with some cucumbers also grown in temperate areas); therefore, they are native to many countries in the world (Ismail et al., 2010). In 2012, FAO statistics revealed a global production of 48 and 65 MT for eggplant and cucumber, respectively (FAOSTAT, 2013). Commonly known as aubergine, eggplants are egg-shaped or globular (Gross et al., 2014) and have a bright green calyx, firm texture and dark purple skin. Cucumber fruit belongs to the Cucurbitaceae plant family and depending on the cultivar, high quality cucumber fruit should be dark green and firm with no wrinkled ends (Gross et al., 2014).

Quality is an important factor in the production and marketing of horticultural crops. When evaluating quality, several parameters in terms of external appearance can play a major role including color, firmness and weight loss, however, the phytochemical attribute is receiving much attention recently in both developed and developing societies (Siddiqui et al., 2016). Although the consumption of fresh fruits and vegetables rich in phytochemicals has been proven to defend against chronic deseases, the stability of these compounds can vary a lot when the food product undergoes postharvest storage prior to consumption (Tiwari et al., 2013). Both eggplant and cucumber are highly perishable and their phenolic content can be affected by postharvest handling practices (Agarwal et al., 2012; Boulekbache-Makhlouf et al., 2013; Mishra et al., 2012). Factors such as temperature and direct sunlight during transportation and storage can determine the synthesis, retention or breakdown of those plant-derived organic compounds (Tiwari et al., 2013). Carotenoids are very sensitive to temperature, light and packaging materials; therefore, they can degrade heavily during storage and processing (Namitha et al., 2010). Studies conducted by Fennema et al. (1996) also revealed that anthocyanin is very susceptible to high temperature and direct light exposure. The rate of phytochemical changes in fresh produce depends on environmental conditions and duration during storage (Shin et al., 2007). Many studies reported that the exposure to undesirable temperatures could exacerbate postharvest phytochemical loss during the handling process (Nath et al., 2011; Padda et al., 2008). These compounds are unstable at higher temperatures (between 25 and 40oC) and relatively stable at lower temperatures (between 4 and 10oC) (Tiwari et al., 2013). Results published by Concellón et al. (2012) showed that minor changes in phenolic antioxidants occurred when dark purple eggplant was stored at 0oC for 14 days compared to a significant accumulation of these organic compounds when stored at 10oC. Beside temperature, exposure to direct light has shown a significant influence on the overall stability of phytonutrients during storage. It is commonly known that phytochemicals are susceptible to degradation due to the occurrence of oxidation during storage (Sanz et al., 2009). In the presence of light, this oxidation process is called photo-oxidation (Tiwari et al., 2013). Studies performed by Xiao et al. (2014) stated that lycopene, anthocyanin and carotenoid were very unstable when exposed to solar radiation and showed higher stability in the dark.

Postharvest storage conditions can foster many chemical composition changes in eggplant and cucumber (Florkowski et al., 2014). These changes occur at different rates, depending on the exposure of the commodity to external environments and the intensity of environmental factors during storage. Kinetic models provide a structural framework for quantitatively describing these changes (Heldman, 2011). The measurement of appropriate kinetic parameters such as reaction rate constant and activation energy for these changes enables the estimation of the magnitude of change in a given food component during storage and prior to final consumption.

The kinetic analysis of phenolic compounds has been extensively investigated in a wide variety of fresh commodities. Cruz et al. (2009) documented that first-order prediction model for ascorbic acid fitted well the experimental data of watercress when stored at different fluctuating cold temperatures. Other studies reported that kinetic parameters were also obtained through first-order models, where the Arrhenius equation was used for temperature-dependence (Kirca et al., 2003; Pinheiro et al., 2013).

Among the many techniques widely used to quantify the phytochemical content in food and biological products, the non-chromatographic UV-VIS spectrophotometric method has proved to be the most simple, quick and inexpensive when not detecting individual phenolic compounds (Tiwari et al., 2013). This method counted on the ability of the phytochemicals to absorb light in the ultraviolet (UV) and the visible range of the spectrum (Samtha et al., 2012): or the ability of producing chromophores after reacting with other reagents (Tiwari et al., 2013). This approach is based on one representative compound or standard for quantification, with the total concentration of the phytochemicals in the plant extract is expressed in terms of equivalent to this standard using a calibration curve. For example, when measuring the total phenolic content (TPC) according to the Folin-Ciocalteu (FC) method, gallic acid, naturally phenolic antioxidant found in plant foods, is usually used as a standard representing the group of polyphenols in the studied crops. These polyphenols react with specific FC reagents to form a blue complex that can be quantified by spectrophotometry (Ainsworth et al., 2007; Sanchez-Rangel et al., 2013). Research on postharvest quality management is experiencing remarkable growth with the emphasis on health-promoting attributes rather than traditional sensory parameters such as color and firmness. The general objective of this study was to investigate the influence of fluctuating environmental factors such as temperature and light, on the phytochemical content of freshly harvested cucumber and eggplant. The specific objectives were to: (1) evaluate changes in the total phenolic content of eggplant and cucumber as influenced by storage conditions, and (2) describe these changes using the kinetic modelling approach.

MATERIALS AND METHODS

Plant material preparation

Fresh cucumbers and eggplants were obtained from a local year-round greenhouse supplier. Right after harvesting, the samples were labelled and separated into experimental units of similar quantity for further analysis.

Experimental set-up

A controlled environment chambers (Conviron Inc., PGR15, Manitoba, Canada) were used in the study. With an internal capacity of 78 ft3, the chambers were fully programmable to monitor set factors (temperature and light). The chamber was capable of maintaining temperature in the range between 10 and 45oC. Airflow inside the unit was distributed uniformly upward using air distribution plenum (Conviron, 2014) that allowed up to 20 ft3/min of air exchange. Light intensity in the chamber was maintained up to 875 micromoles/m2/s or 64750 lux using fluorescent and incandescent lamps. This is the typical average of sunlight intensity during a sunny day.

Under constant storage conditions (SC): samples of eggplant and cucumber were stored at 10 and 30oC for 10 days with 90□5% RH. Experiments were conducted under 2 different light scenarios namely complete darkness and an interval of 12 hours of direct light per day for each temperature setting. A total of four different storage combinations of temperature and light were conducted as follow: SC1 = 100C (with light); SC2 = 300C (with light); SC3 = 100C (without light); SC4 = 300C (without light). The storage at 10oC represented the optimum conditions for commercial storage recommended for studied crops (Gross et al., 2014); whereas, the second temperature (30oC) corresponded to the average annual temperature that best characterize tropical countries where temperature abuse during postharvest handling is more frequent.

Under fluctuating conditions, the storage of cucumber and eggplant was simulated based on real situations occurring during the handling process of fresh produce in many countries around the world (Figure 1). After harvesting, the crop samples were stored at 25oC for 2 hours with no light exposure (S1). This step was similar to the activity carried out by farmers in the field, where they place their crop under shade after harvesting. The following step (S2) was to store the cucumber and the eggplant for 3 hours under light, which simulated the transportation of the fresh produce to the market using open trucks. Step 3 corresponded to the marketing stage of the harvested commodity for a typical duration of three consecutive days under fluctuating conditions of temperature and light between day and night. Therefore, the crop samples were stored at 30oC with light for 12 hours and at 20oC with no light for another 12 hours. This step (S3) lasted for 72 hours. The final step (S4) illustrated conditions similar to what happened at the consumption level where the produce was stored at low temperature (10oC) in the absence of light for a maximum duration of 6 days (144 hours). The entire experiment was conducted in triplicate.

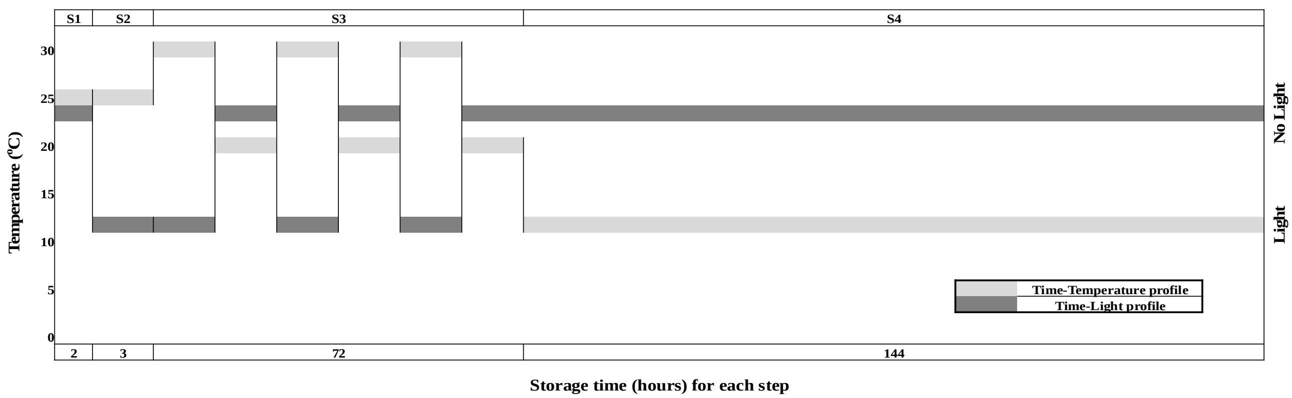

Figure 1. Schematic diagram of fluctuating environmental conditions during storage

Methanolic/Acetonic extraction

Frozen samples of eggplant and cucumber were freeze-dried using freeze-dryer (Modulyod-115; ThermoSavant, Holbrook, NY, USA) until equilibrium at -52oC (48 hours). Dried samples were then pulverized into fine powder using a mortar and a pestle. After that, 100 mg portions of pulverized dried sample were placed into 15 ml plastic tubes. Then, 4 ml of solvent (methanol 90% for cucumber and acetone 90% for eggplant) were added (Boulekbache-Makhlouf et al., 2013). The mixture was bath-sonicated (Branson Ultrasonic Inc., 5510, USA) for 45 min with ice and then vortexed manually. The solution was then centrifuged at 3500 rpm for 15 min at 4oC (Jouan CR4.22, bench-model, Canada). First supernatant was collected in clean tubes and the pellet was re-extracted by adding 1 ml solvent and centrifuged again. A second supernatant was then collected and added to the first one. Finally, clear supernatants of both eggplant and cucumber dry weight (DW) extracts were stored at -20oC for further analysis.

Determination of phenolic content

The total phenolic content of both crop extracts was quantified following the technique of Singleton and Rossi (1965) by using the Folin-Ciocalteu assay with few modifications. Clear supernatant of 100 µl was added to 2 ml distilled water and 200 µl of Folin-Ciocalteu phenol's reagent (2N). After few minutes, the solution was mixed with 1 ml of Na_2CO_3 (10%) and incubated in the dark at room temperature for 60 min. The absorbance was then read at 765 nm using UV-Vis spectrophotometer (UV1; Thermo Fisher Scientific Inc, Canada). Total phenolic content was obtained by a linear equation using gallic acid as the standard (y = 2.2892x + 0.0042, R2 = 0.99). Each sample's extract was measured in triplicate and an average value was recorded. Finally, the total phenolic content of eggplant and cucumber was determined as a milligram gallic acid equivalent (GAE. mg/ml extract).

Data and statistical analyses

Changes in phytochemical content of cucumber and eggplant as affected by different storage conditions were analyzed. For all storage conditions, zero, first and second order reactions were plotted against time (days) and the highest coefficient of determination (R^2) was obtained from a linear regression analysis, thus providing the accuracy of the first order kinetic model.

Under isothermal conditions, a fractional kinetic model described by equation 1 was used to quantify phytochemical change. The average retention of TPC at a given time was determined using the following formula:

$$\frac{C_t}{C_0} = \exp^{-kt} \tag{1}$$

where C_t is the measured quality parameter (TPC) at time t, C_0 is the initial quality before any storage, t is the storage time and k is the rate constant at temperature T.

The temperature-dependence of the rate constant "*k*" followed the Arrhenius equation (Eq. 2):

$$k = k_{ref} \exp\left[\frac{-E_a}{R}\left(\frac{1}{T_i} - \frac{1}{T_{ref}}\right)\right] \tag{2}$$

where k_{ref} is the reaction rate at reference temperature (T_{ref}): E_a is the activation energy of the reaction (J/mol): R is the universal gas constant (8.314 J/mol.K) and T is the absolute temperature (K). The reference temperature used was 30°C.

By substituting equation 2 into equation 1, the general model that expresses the phytochemical changes (loss or accumulation) due to temperature and light effect can be described as follows (Eq. 3):

$$\frac{C_t}{C_0} = \exp^{-k_{ref} \exp\left[\frac{-E_a}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right] t} \tag{3}$$

Under non-isothermal conditions, the total phenolic content can be predicted for a given time by equation 4:

$$\frac{C_t}{C_0} = \exp^{k_{ref} \int_0^t \exp\left[\frac{-E_a}{R}\left(\frac{1}{T_i} - \frac{1}{T_{ref}}\right)\right] dt} \tag{4}$$

By introducing the term of effective temperature (*T_{eff}*) as demonstrated by Giannakourou et al. (2003) and defined as the constant temperature at which the same quality change resulted from the same time duration as the temperature fluctuated along the storage, the total phytochemical changes for the entire storage duration of studied crops as influenced by fluctuating temperature and light can then be predicted using the equation 5:

$$\frac{C_{t_{total}}}{C_0} = \exp^{-k_{eff} t_{total}} \qquad (5)$$

where k_{eff} is the value of the rate constant at the effective temperature. Therefore, $k_{eff}\, t_{total}$ was calculated using equation 6:

$$k_{eff} t_{total} = k_{ref} \sum_i \left(\exp\left[\frac{-E_a}{R} \left(\frac{1}{T_i} - \frac{1}{T_{ref}} \right) \right] t_i \right) \qquad (6)$$

An analysis of ANOVA followed by a Tukey-Kramer HSD test for comparison of means was conducted using JMP version 11 software.

RESULTS AND DISCUSSION

Effect of storage temperature and light on total phenolics

Figures 2 and 3 showed the phytochemical concentration of freshly harvested dark purple eggplant and cucumber fruits under different storage conditions. Under complete darkness, TPC decreased during high storage temperature. After 10 days at 30^{o}C, phenolic contents decreased from 0.33 to 0.18 mg GAE/ml eggplant extract (44.5% loss) and from 0.09 to 0.06 mg GAE/ml cucumber extract (37% loss). However, an opposite trend was significantly observed ($P < 0.05$) in the absence of light when crops were stored at 10^{o}C. An accumulation of 33 and 90% for eggplant and cucumber, respectively, was recorded at day 10, compared to the initial concentration. These results were in agreement with other studies demonstrating that storage temperature is a key parameter for the degradation or the retention of phytochemicals in vegetables (Zaro et al., 2014b). Therefore, maintaining optimum temperature conditions during storage is extremely important to promote health-benefit attributes in postharvest quality management of fresh produce. Studies have also shown that the stability of phenolic compounds greatly depended on undesirable temperatures. Studies carried out by Concellón et al. (2012) and Zaro et al. (2014a) showed that there was an increase in phenolic content of eggplant cultivars stored at 10^{o}C for 14 days and this accumulation was correlated to chlorogenic acid biosynthesis, a bioactive compound at this temperature. Others have reported lower stability of potato and radish anthocyanin at 25^{o}C compared to 2^{o}C (Tiwari et al., 2013). It was noticed that kinetics of some antioxidants present in these crops followed much faster reaction rates at higher temperatures as well as quadratic model under 25^{o}C and linear model at 2^{o}C.

Figures 2 and 3 revealed also the results of TPC as affected by direct exposure to light during storage. Under isothermal conditions (10^{o}C): there was a significant break-down ($P < 0.05$) in phenolic concentration due to photo-oxidation with light. In the case of eggplant, the phytochemical content degraded by 42%, while in cucumber, around 35% loss was observed after 10 days of storage. On a different note, there was a continuous drop of TPC when produce was stored at 30°C. A greater loss ($P > 0.05$) of phytochemicals (56 and 52%) was noticed under direct exposure of light compared to 45 and 37% degradation under complete darkness in both eggplant and cucumber, respectively. Similarly under 10 and 30°C with exposure to light, the results revealed a continuous decrease of phytonutrients of both crops with no significant difference between the two storage conditions. Therefore, exposure of fresh crops to light for 12 hours/day at both 10 and 30°C has a great influence on degrading phytochemical content same as high temperature (30°C) under complete darkness. A similar conclusion has been reported by Lin et al. (2005) and Nachtigall et al. (2009) where they demonstrated that lycopene destruction was more severe due to light effect than to high temperature.

It is often difficult to ensure constant storage conditions during postharvest handling of fresh commodities. In many countries, fresh fruits and vegetables experienced severe stress along the postharvest process due to fluctuating temperature and direct sunlight. Consequently, this resulted in major qualitative and quantitative losses. Figure 4 illustrated the phytochemical behavior of fresh eggplant and cucumbers as they moved from farm to fork. During the first two hours of storage (S1): TPC decreased by almost 2 and 6% for eggplant and cucumber, respectively. A continuous degradation of phenolic compounds occurred when the crops were exposed to light for a subsequent three hours (S2) with higher loss (~15%) in the case of cucumber. The results also demonstrated a significant ($P < 0.05$) degradation of total phenolics after 3 consecutive storage days (S3) of fluctuating temperature and light with a corresponding phytochemical loss for eggplant and cucumber ranging from 50 to 84%. After that, when the produce was stored in darkness at 10°C for another 6 days (S4): phenolic antioxidants were significantly ($P < 0.05$) built up to 86 and 92% of the initial concentrations for both eggplant (0.285 mg GAE/ml extract) and cucumber (0.091 mg GAE/ml extract).

Fluctuating the temperature and light along the supply chain process has been always associated with major quality loss of fresh food commodities. This statement is in agreement with a study carried out by Cruz et al. (2009) where they concluded that temperature abuse was the main problem affecting food quality during storage and a lower and constant temperature was needed to minimize food quality losses. Finally, the present work showed that the phytochemical content of eggplant and cucumber fruits was greatly affected by postharvest storage temperatures and light. The synthesis observed at 10°C in the absence of light considerably increases the nutritional value of the produce and the benefits related to the consumption of antioxidants (Concellón et al., 2012).

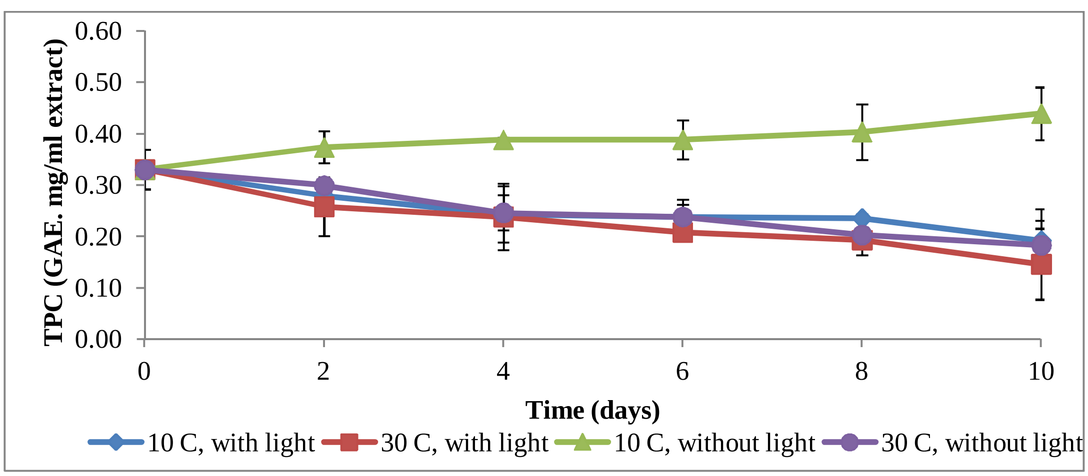

Figure 2. Total phenolic content at constant storage conditions for eggplant

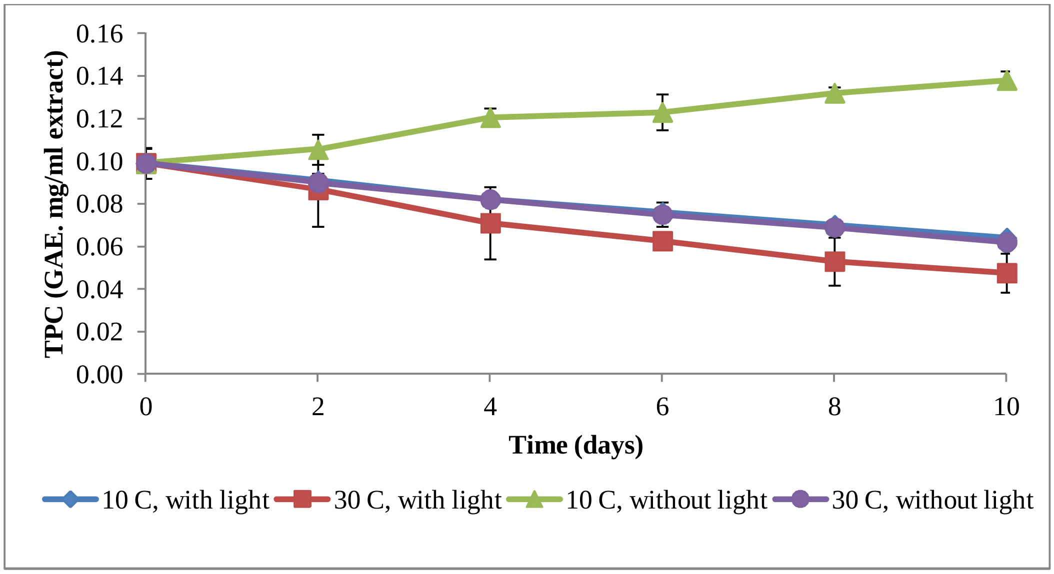

Figure 3. Total phenolic content at constant storage conditions for cucumber

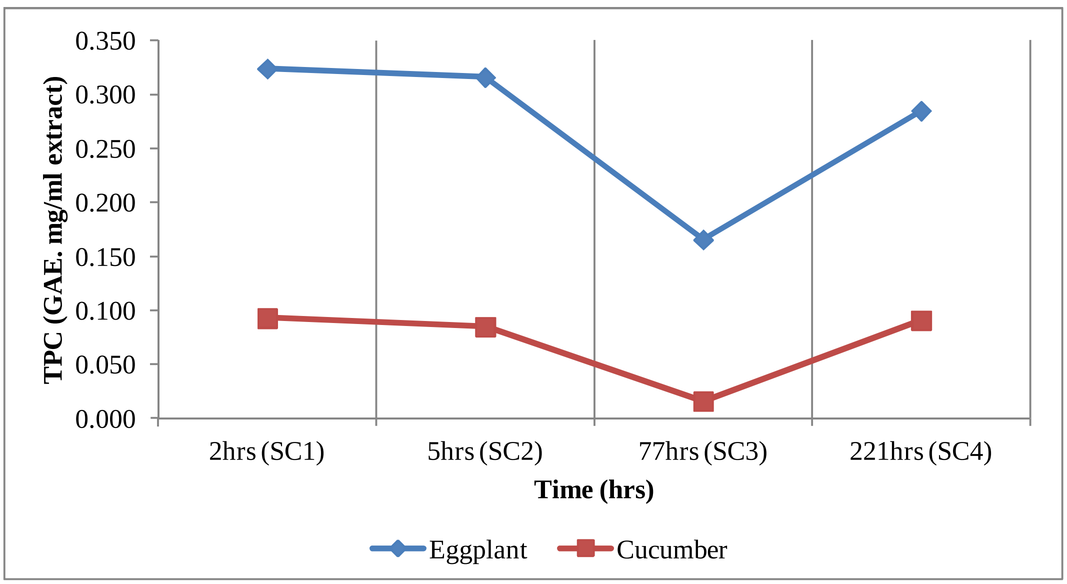

Figure 4. Total phenolic content at fluctuating storage conditions for eggplant and cucumber

Phytochemical changes during storage

Kinetic analysis at constant conditions

Studying kinetics was necessary to predict the change in postharvest health attributes and the influence of temperature and light on the phytochemical content of studied crops during storage. Table 1 showed the kinetic parameters of eggplant and cucumber at both studied temperatures 10 and 30^{o}C obtained under the absence and the presence of light. Experimental data of TPC fitted well the first order reaction model (Eq. 1). During storage (SC1, SC2 and SC4): the total phenolic concentration in both eggplant and cucumber was decreased gradually over time at a rate depending on the temperature and light exposure. For both crops, the degradation was faster at 30^{o}C under direct light ($k_{eggplant}$ = 0.073/day; $k_{cucumber}$ = 0.075/day). It was also important to mention that the phenolic content was degrading at almost similar rate when crops were stored at 10^{o}C with light and 30^{o}C without light. Therefore, this concluded that even at lower temperature, direct exposure of light has the same impact on phytochemical loss as higher temperature. On a different note, total phenolic content was gradually increased with time at a slower reaction rate during storage at 10^{o}C under complete darkness ($k_{eggplant}$ = 0.024/day; $k_{cucumber}$ = 0.034/day).

An Arrhenius equation describing the temperature-dependence (Eq. 2) with $T_{30}{}^{o}{}_{C}$ as reference temperature was used to calculate the activation energy for both studied crops. In the study, two different "Ea" were obtained for each produce considering the light factor. The results (Table 1) revealed that energy needed to start the phenolic concentration change within the food system was Ea = 16.05 and 19.62 KJ/mol for eggplant and cucumber, respectively. In contrast, higher Ea values were recorded in the absence of light (39.94 KJ/mol for eggplant and 28.84 KJ/mol for cucumber). Once again, this concluded that exposure to light was a major environmental factor to be carefully considered during postharvest quality management of fresh fruits and vegetables.

Table 1. Kinetic parameters of eggplant and cucumber at constant storage conditions.

Storage Conditions	C_0	C_{eq}	Kinetic parameters		
			k (day^{-1})	R^2	Ea (KJ/mol)
Eggplant					
SC1	0.330	0.192	0.046	0.906	16.05
SC2	0.330	0.146	0.073	0.961	
SC3	0.330	0.439	0.024	0.889	39.94
SC4	0.330	0.183	0.059	0.981	
Cucumber					
SC1	0.099	0.064	0.044	0.998	19.62
SC2	0.099	0.048	0.075	0.994	
SC3	0.099	0.138	0.034	0.961	28.84
SC4	0.099	0.062	0.046	0.999	

SC1 = 10^{0}C (with light); SC2 = 30^{0}C (with light); SC3 = 10^{0}C (without light); SC4 = 30^{0}C (without light).

Table 2. Kinetic parameters and predicted TPC loss of eggplant and cucumber at fluctuating storage conditions.

Storage period (hours)	C_0	C_{eq}	Kinetic parameters	Predicted TPC loss (%)
			$k_{eff}\, t_{total}$	
Eggplant				
2	0.330	0.324	0.046	4.49
5	0.330	0.316	0.128	12.01
77	0.330	0.166	1.860	84.43
221	0.330	0.285	0.430	34.94
Cucumber				
2	0.099	0.093	0.051	4.97
5	0.099	0.085	0.133	12.45
77	0.099	0.016	2.019	86.72
221	0.099	0.091	0.014	1.39

Kinetic analysis at fluctuating conditions

Kinetic parameters determined under isothermal conditions were used to establish kinetic models under fluctuating temperature and light. Under non-isothermal storage, the effective reaction rates "k_{eff}" multiplied by the cumulative storage time "t_{total}" at each step in Figure 1 were calculated and presented in Table 2. At the first stage of the storage (time = 2 hours): the phytochemical loss occurred at slower rates ($k_{eff}\,t_{total}$ = 0.046 and 0.051) resulting in predicted TPC loss of 4.5 and 5% for eggplant and cucumber, respectively. However, at the end of the second stage (time = 5hours): phenolic degradation under the same temperature of 25^{o}C was higher ($k_{eff}\,t_{total}$ = 0.128 and 0.133) due to light effect with phenolic losses of about 12% for both crops. After 77 hours of variable storage conditions of temperature and light, between 84 and 86% loss resulted for eggplant and cucumber, respectively, with $k_{eff}\,t_{total}$ = 1.860 and 2.019. When the produce was stored for 144 hours at 10^{o}C in completed darkness, an accumulation of phenolic antioxidants was observed and a predicted loss of 35% for eggplant and 1.4% for cucumber of the initial concentration was observed ($k_{eff}\,t_{total}$ = 0.430 and 0.014). Concellón et al. (2012) also found an increase of phenolic antioxidant values to harvest when the dark purple American eggplant samples were maintained at 10^{o}C after 5 and up to 14 days of storage. Based on Table 2, the extent of phytochemical behavior varied a lot between crops; therefore, an accurate prediction of the TPC changes as affected by temperature and light fluctuation is always a function of estimated kinetic parameters determined under isothermal conditions (Cruz et al., 2009).

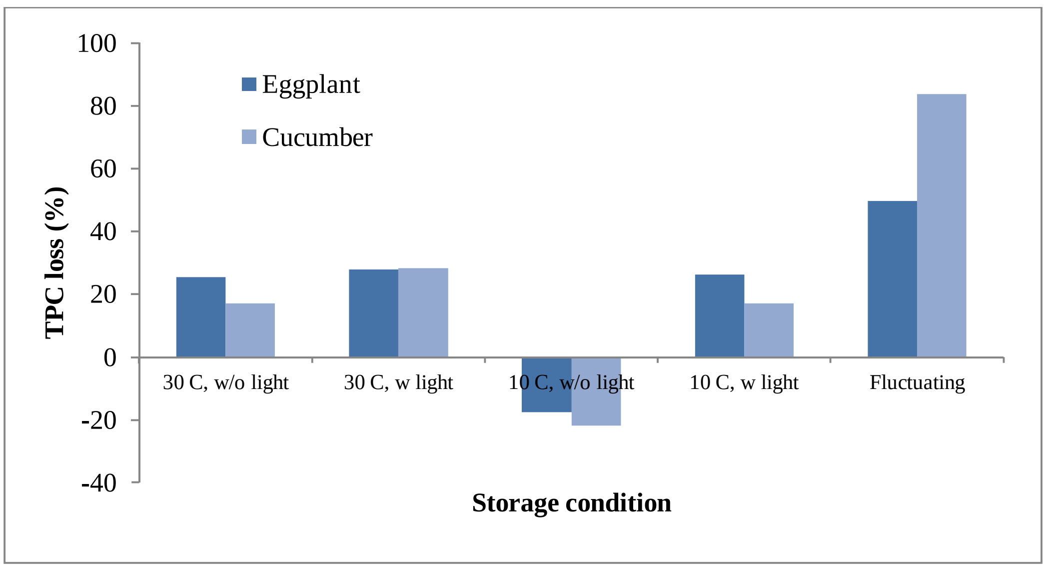

Figure 5. Comparison of TPC percent loss after 77 hrs of storage to harvest for both eggplant and cucumber as affected by constant and fluctuating storage conditions.

Comparison of TPC loss

In this experiment, fresh eggplant and cucumber fruits were stored for 10 days under various conditions. Under fluctuating temperature and light, the majority of TPC loss occurred during the first 77 hours (equivalent to day 4 under isothermal conditions) of storage that corresponded to early stages in the supply chain (production and marketing stages) where most of postharvest losses are frequent in many countries around the globe (especially in developing societies). This storage duration corresponded to almost day 4 under constant conditions. Figure 5 showed the percent loss of phenolic content in both eggplant and cucumber under the four constant conditions compared to fluctuating storage. The results revealed that highest losses occurred under variable storage temperature and light followed by losses at a constant temperature of 30°C with direct exposure to sunlight. In other words, temperature and light abuses during postharvest handling and prior to consumption of fresh horticultural commodities increased phytochemical losses by two- to three-fold for eggplant and cucumber, respectively. Therefore, the impact of fluctuating environmental factors was detrimental to phytonutrients of fresh produce during postharvest storage.

CONCLUSION

The environmental conditions under which fresh crops are produced, transported and displayed have a significant effect on the keeping quality of the food and the amount that is lost. Exposure to light showed a similar influence on retention and/or degradation of phytochemical content same as high temperature. Furthermore, fluctuating conditions right after harvesting and during the handling process caused greater phytonutrient losses than constant storage at 30oC in the presence of light. Therefore, enhancing postharvest quality management from farm to fork through maintaining low temperature of 100C with complete darkness can significantly reduce postharvest phytonutrient quality loss. Finally, kinetic models were quite useful in predicting the degradation of the total phenolic content of fresh commodities during storage and commercialization and therefore allowed for a better assessment of quality at each step along the supply chain.

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