J. Agric. Sci. Technol. (2024) Vol. 26(1): 85-95

Changes in Bioactive Compounds, Decay Rate, and Chilling Injury of Pumpkin Stored at Different Temperatures

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ABSTRACT

The effects of storage temperature on bioactive compounds, decay, and chilling injury development of pumpkins during cold storage and shelf-life periods were examined. In the present study, fruits were stored at 3°C, 8°C, and ambient temperature (control) for 180 days and, after that, fruits were stored at 20°C for 7 days to determine shelf-life performance. The lowest weight loss was found in the fruit stored at 3°C during cold storage while the highest flesh firmness was found on the fruit stored at 8°C. Total soluble solids, L-ascorbic acid and glucose contents were found to be higher in the fruit stored at 3°C compared to other storage temperatures. The highest total carotenoid content and the lowest decay incidence were recorded by the fruit stored at 3 and 8°C. Fruit stored at 3°C showed better quality parameters as compared to other temperatures under study. Although 3°C was better to protect the biochemical composition of pumpkin fruits, decay rate increased at this temperature due to chilling injury. It is concluded that the storage temperature of 8 °C was optimum to maintain fruit quality and biochemical contents and to inhibit decay during long-term storage of pumpkins.

Keywords: *Cucubita moschata Duch*., Postharvest storage, Pumpkin fruit quality, Shelf-life performance.

INTRODUCTION

Interest in the nutritional and health benefits of fruits and vegetables has been increasing due to their preventive effects on human diseases (Yahia *et al*., 2018). Pumpkin (*Cucubita moschata Duch.*) is included in the category of functional vegetables because it contains higher phenolics, flavonoids, vitamins, amino acids, and carbohydrates (Zhang *et al*., 2000). Due to these rich contents, pumpkins are widely known in different frameworks of customary medicine such as anti-diabetic, anti-hypertensive, anti-cancer, immune regulation, antibacterial, cholesterol-lowering, intestinal antiparasitic, anti-inflammatory and analgesic (Fu *et al*., 2006). The demand of the perishable fruits and vegetables created extreme pressure on the fresh produce industries to supply enough food to the increasing population. One way to encounter demand is to diversify crops and use appropriate postharvest technologies to reduce postharvest losses in supply chains (Sharma and Ramana Rao, 2013). Postharvest processing, packaging and cool chain could be employed to maintain fruit quality for better usability and market return (Nanda *et al*., 2001). During the food chain, cold storage is one of the effective methods to control quality (Bourne, 2004). However, if suitable storage temperatures are not chosen, fruit suffers from chilling injury especially in warm climates (Hong and Gross, 2001).

Alternative consumption and preservation methods of pumpkin such as drying (Junqueira *et al*., 2017) and minimally processed (Huynh and Nguyen, 2020; Survase *et al*., 2021) were also investigated. However, due to a huge production quantity, even these methods are not enough to process all pumpkin products. Hence, postharvest storage can be

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[DOI: 10.22034/JAST.26.1.85]

effectively managed under controlled temperature to protect quality and postharvest loss in fruits and vegetables. Storage temperature was very effective to control postharvest quantity and quality loss in two different pumpkins stored at 27-31°C and 75-90% RH for 120 days (Rahman *et al*., 2013). Biesiada *et al*. (2011) also stored different pumpkin varieties at 10°C and 75% RH for 90 days and reported that pumpkin varieties showed different responses depending on storage temperature. Gibe and Lee (2008) investigated chilling injury in winter squash stored at 5 and 12°C for 180 days and reported that chilling injury symptoms were observed after 2-4 months storage depending on cultivars. There are few published reports revealing the effects of different temperatures on pumpkin chilling injury, decay and maintaining postharvest quality during storage. Therefore, we aimed to study the effect of storage temperature on biochemical composition, decay, and chilling injury development in pumpkins during both cold storage and shelf-life period in the present work.

MATERIALS AND METHODS

Fruit Material and Storage Conditions

The study was carried out on pumpkins (*Cucurbita moschata Duch.*) harvested from a commercial field in Antalya, Turkey. After harvest, fruits were immediately brought to the postharvest laboratory and were divided into three lots. The first and second lot of pumpkins were stored at 3±0.5 and 8±0.5°C with 70±5% relative humidity (RH), respectively. The third lot of pumpkins was stored at ambient temperature without cooling (control). Following removal from cold storage, the pumpkin fruits were also kept for 7 days at 20±3°C to simulate the shelf-life performance. Fruit samples were removed from cold storage at 60 days interval until 180 days of cold storage for quality evaluation.

Experimental Method

The fruits were numbered and weighed at the beginning of the experiment to determine the amount of weight loss. Fruits at the end of each storage time were reweighed, and results were calculated as per cent loss from initial weight. The flesh firmness measurements were also carried out at three different points after removing the peel with 0.5 cm thickness. In firmness measurement, a penetrometer (FT 327) with an 8-mm probe was used. The peeled fruits were shredded with a juicer obtaining the juices to be used to determine Total Soluble Solids (TSS) and Titratable Acidity (TA). While TSS (%) was determined using digital hand refractometer, TA was measured with a method reported by Provesi *et al*. (2011) and the results were expressed as % citric acid equivalents.

Extracted L-Ascorbic Acid (AA) from pumpkins was measured according to a method described by Karhan *et al*. (2004). L-ascorbic acid was extracted with 6% (v/v) metaphosphoric acid and 1 mL extract was filtered through 0.45 μm Teflon filter and injected into the HPLC. The chromatographic conditions were adjusted to following procedure: Column= Reverse phase C18 column, Mobile phase= 25 mM KH_2PO_4, pH= 3.0 isocratic flow, Flow rate= 1 mL min^{-1}, Injection volume= 20 μL, Analysis time= 15 minutes, Exit time= 2.4 minutes, Column temperature= 25 °C, Wavelength= 254 nm, Detector= DAD. The total amount of carotenoids was determined according to the method described by Cemeroğlu (2007). Briefly, 30 g fruit puree was homogenized with 5 g of HyfloSupercel and 75 mL of methanol (70 %). The mixture was filtered, and the residue of the mixture was extracted substantially twice, using 75 ml of acetone-petroleum ether in the ratio of 1:1 (w/w). The extracts were placed in a separating funnel with 25 mL KOH (10 %) and shaken for 45 min. This process was repeated using 75 mL petroleum ether and 100 mL NaCl (20 %). Finally, epiphasic layer was filtered using anhydrous Na_2SO_4. The sample was read

[DOI: 10.22034/JAST.26.1.85]

using spectrophotometer at 438 nm. The sugar contents were determined according to the method described by Lefebvre *et al*. (2002). Briefly, 5 g fruit sample was homogenized with 45 mL distilled water, and the mixture was incubated at 40°C for 30 minutes in ultrasound water bath operating at a frequency of 40 kHz. After incubation, the samples were centrifuged at 4,000×g for 5 minutes. A 1 mL supernatant was filtered 0.45 µm, and extraction procedure was done.

To determine decay rate, visual observations were done according to a method that the fruits with visible mold growth on the surface were evaluated as decayed, and the results were given as a percentage of total fruits. In addition, decay index was evaluated using 0-10 scale, explaining the severity of postharvest decay (0= No decay; 1= Decay area≤ 10%; 2= 11-20%; 3= ≤ 21-30%; 4= 31-40%; 5= 41-50%; 6= 51-60%; 7= 61-70%; 8= 71-80%; 9= 81-90%; 10= 91-100%) (Holb and Schnabel, 2007). The symptoms of chilling injuries were pitting on the pell and tissue softening and watering in the flesh. The overall Chilling Injury (CI) was determined based on individual evaluation of each fruit according to a 6-point scale (0 = no symptoms; 1= 1–20%; 2= 21–40%; 3= 41–60%; 4= 61–80% and 5= > 81%) (Garcia-Pastor *et al*., 2020).

The experiment was carried out by completely randomized factorial design with three replicates. Mean and standard error of mean were calculated for each parameter. Additionally, Analysis Of Variance (ANOVA) was performed using the SAS 9.0 statistical software and means were compared using Duncan's multiple range test (P≤ 0.05).

RESULTS AND DISCUSSION

Weight Loss

No statistically significant differences were recorded between pumpkins stored at 3 °C and 8 °C for 60 and 120 days. At 180th day of storage, the lowest weight loss was found in the fruit stored at 3°C (10.20%) while the highest was noted in control treatment (20.38 %) (Figure 1-A). Similar trend was also observed with respect to shelf-life (Figure 1-B). The results indicated that decreasing temperatures were effective to prevent weight loss of pumpkins for cold storage and shelf life. Arvayo-Ortiz *et al*. (1994) reported that storage duration and temperature positively affect the weight loss in winter squash. It is considered that the weight loss can be reduced by cooling the fruit at appropriate temperature, as it helps to slow down metabolism, respiration, and transpiration rates. The weight loss of pumpkins stored at 27-31°C with 75-90% RH for 120 days can reach up to 18-21% depending on variety (Rahman *et al*., 2013).

Total Soluble Solids (TSS) and Titratable Acidity (TA)

As the storage period increased, the TSS content decreased, depending on the storage temperatures (Figures 2-A and -B). At harvest, the initial TSS content of pumpkins was 11.2%, which exhibited a decreasing trend with increase in storage period. At the end of 180 days storage, TSS was 5.4, 5.0 and 4.7% in pumpkins stored at 3°C, 8°C and control treatments, respectively (Figure 2-A). Similar trends were observed with respect to shelf life of the pumpkin fruits (Figure 2-B). On the other hand, the initial TA content of pumpkins was 0.48% and, after 180 days storage, the pumpkins stored at 3 and 8°C were higher in TA content (0.15 and 0.18%) than those stored at ambient temperature (Figure 3-A). A similar trend was observed during shelf life (Figure 3-B). The TSS content of the pumpkins varied from 3.0 to 8.7% among 7 different cultivars originating from Poland, Lithuania and Russia (Gajewski *et al*., 2008). Another study conducted by Balkaya *et al*. (2010) in Black Sea region of Turkey indicated that TSS contents of 17 cultivars ranged from 3.4 to 7.5%. The results of the present study agree with both Gajewski *et al.* (2008) and Balkaya *et al*. (2010). The decrease in TSS and TA in pumpkin storage might be due to changes in metabolism of fruit or the use of organic acids

[DOI: 10.22034/JAST.26.1.85]

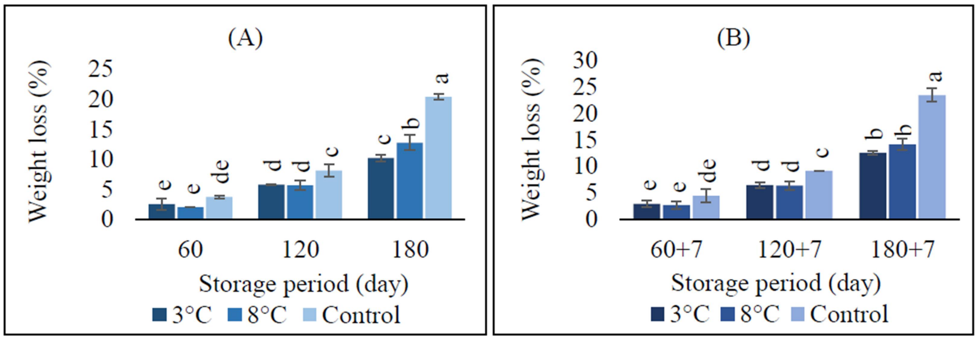

Figure 1. Weight loss in different storage periods (A) and +7 day at 20 °C (B).

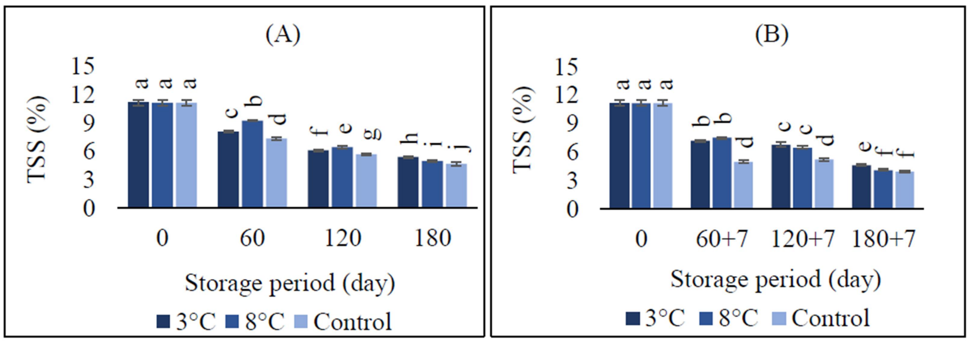

Figure 2. TSS in different storage periods (A) and +7 day at 20°C (B). TSS: Total Soluble Solids.

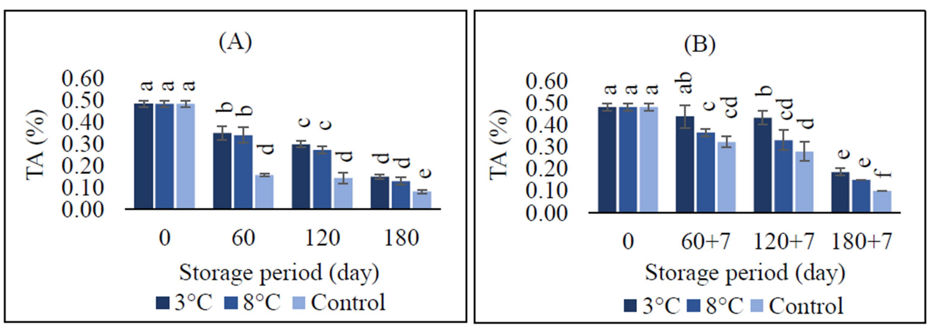

Figure 3. TA in different storage periods (A) and +7 day at 20 °C (B). TA: Titratable Acidity.

during respiration (Echeverria and Valich, 1989). Decreasing trend in TSS and TA was supported by Rahman *et al*. (2013). Unlike these, Biesiada *et al*. (2011) claimed that decreasing or increasing trends of TA during storage can alter based on varieties.

Fruit Firmness

The extension in storage period significantly decreased the fruit firmness depending on the storage temperatures (Figures 4-A and -B). At the end of 180 days storage, the fruit firmness of pumpkins stored at 8°C (73.7 N) was higher than those stored at 3°C (64.7 N) and ambient temperature (66.4 N) (Figure 4-A). Similarly, pumpkins stored at 3 °C had the lowest fruit firmness at 120+7 day of storage than those stored at 8°C and ambient temperature (Figure 4-B). Fruit firmness of fresh-cut pumpkins was negatively affected by storage time and temperatures (Amodio

[DOI: 10.22034/JAST.26.1.85]

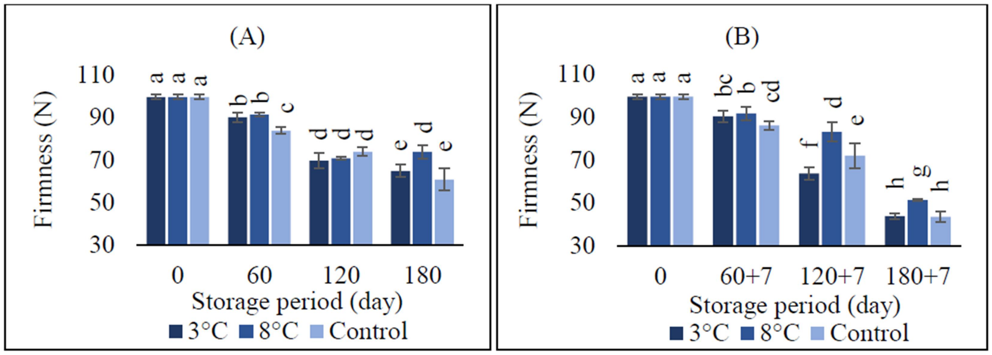

Figure 4. Firmness in different storage periods (A) and +7 day at 20°C (B).

et al., 2010). Similarly, the decrease in fruit firmness was faster at high temperatures as compared to lower temperatures in three different muskmelon cultivars (Yuan *et al*., 2013). Marangoni *et al*. (1995) also reported that fruit firmness of pre-chilled fruit and tissue was lower than non-chilled tomatoes due to increasing activity of cell wall enzymes such as Polygalactronase (PG) and Pectinmethylesterase (PME) in heat stress.

L-Ascorbic Acid (AA) Content

The initial AA content of the pumpkins was 7.01±0.18 mg 100 g^{-1} fresh weight (fw) and significantly decreased during storage depending on storage temperature (Table 1). After 180 days storage, the highest AA content was found in fruit stored at 3°C with 5.41±0.31 mg 100 g^{-1} fw, and lowest for the control fruits with 3.12±0.01 mg 100 g^{-1} fw (Table 1). Similarly, the lowest AA value was found in control fruit with 2.73±0.02 mg 100 g^{-1} fw at the end of 180+7 days of shelf-life (Table 2). AA content of the fruits and vegetables is affected directly or indirectly by pre- and post- harvest treatments (Marangoni *et al*., 1995). Zinash and Woldetsadik (2013) indicated that the ascorbic acid content of 20 different pumpkin varieties ranged between 4.81 to 9.1 mg 100 g^{-1} fw. AA is one of the most important vitamins to decrease when horticultural crops are subjected to unfavorable handling and storage conditions. Many factors such as extended storage time, higher temperature, lower relative humidity, physical damage and chilling injury can accelerate loss of AA (Lee and Kader, 2000). In this study, although AA loss occurs during cold storage in all temperatures, it was more obvious in the control. It is thought that this situation is caused by the acceleration of metabolism and respiration process in the control fruits that are stored at higher temperatures. Similarly, AA content in 2 different pumpkin varieties decreased sharply at the end of 120 days storage period in ambient conditions (Rahman *et al*., 2013). The level of AA decreased by 40 % in pumpkin fruit stored at 10°C with 75% RH after 90 days storage (Biesiada *et al*., 2011).

Total Carotenoids (TC)

In the present study, the initial TC content of the pumpkins was 6.64 mg 100 g^{-1} fw, which agreed with data reported by Dinu *et al*. (2016). TC contents in pumpkins gradually decreased during the storage period, and this reduction was effectively slowed down by the storage temperature (Tables 1 and 2). At the end of storage, although fruit stored at 3 and 8°C had higher total carotenoids than the control fruit, there were no significant differences between fruit stored at 3 and 8°C. While the highest TC contents were found in fruit stored at 3 and 8°C with 1.65±0.01 and 1.59±0.08 mg 100 g^{-1} fw, the lowest was found

[DOI: 10.22034/JAST.26.1.85]

Table 1. L-ascorbic acid, total carotenoids, sucrose, glucose, and fructose content of pumpkins stored at different temperatures. [a]

Treatments	Storage time (Days)	L-Ascorbic acid (mg 100 g^{-1})	Total Carotenoids (mg 100 g^{-1})	Sucrose (g 100 g^{-1})	Glucose (g 100 g^{-1})	Fructose (g 100 g^{-1})
Initial	0	7.01 ± 0.18 a*	6.64 ± 0.04 a	1.76 ± 0.02 ab	0.50±0.10d	0.84 ± 0.03 b
3°C	60	5.96 ± 0.28 b	3.41 ± 0.32 b	0.54 ± 0.07 e	0.70±0.05c	0.67 ± 0.5 bcd
8°C		5.60 ± 0.03 c	2.64 ± 0.06 c	0.41 ± 0.07 e	0.94±0.04b	1.03 ± 0.09 a
Control		4.40 ± 0.16 d	1.95 ± 0.06 d	0.64 ± 0.03 de	1.29±0.10a	1.11 ± 0.03 a
3°C	120	5.61 ± 0.36 c	2.43 ± 0.31 c	1.77 ± 0.77 ab	0.39±0.19d	0.23 ± 0.13 e
8°C		4.64 ± 0.04 d	1.81 ± 0.13 de	2.11 ± 0.10 a	0.40±0.03d	0.52 ± 0.04 d
Control		3.89 ± 0.18 e	1.34 ± 0.04 fg	0.52 ± 0.26 e	0.14±0.03e	0.51 ± 0.07 d
3°C	180	5.41 ± 0.31 c	1.65 ± 0.01 e	1.00 ± 0.31 cd	0.90±0.08b	0.64 ± 0.10 cd
8°C		4.61 ± 0.08 d	1.59 ± 0.08 ef	1.32 ± 0.13 bc	0.59±0.34cd	0.82 ± 0.23 b
Control		3.12 ± 0.01 f	1.17 ± 0.35 g	1.29 ± 0.32 c	0.58±0.05cd	0.70 ± 0.16 bc

[a] Data are the mean±SE. Different letters in the same column indicate significant difference at P≤ 0.05 probability.

Table 2. L-ascorbic acid, total carotenoids, sucrose, glucose, and fructose content of pumpkins stored at different storage temperatures at the end of shelf life of 7 day at 20°C. [a]

Treatments	Storage times (Days)	L-Ascorbic acid (mg 100 g^{-1})	Total carotenoids (mg 100 g^{-1})	Sucrose (g 100 g^{-1})	Glucose (g 100 g^{-1})	Fructose (g 100 g^{-1})
Initial	0	7.01 ± 0.18 a*	6.64 ± 0.04 a	1.76 ± 0.02 ab	0.50 ± 0.10 a	0.84 ± 0.03 a
3°C	60	5.94 ± 0.09 b	5.55 ± 0.05 b	1.09 ± 0.04 cd	0.24 ± 0.04 d	0.13 ± 0.07 c
8°C		4.62 ± 0.33 d	2.41 ± 0.85 c	0.37 ± 0.24 f	0.36 ± 0.03 c	0.58 ± 0.15 ab
Control		3.83 ± 0.15 e	2.08 ± 0.20 cde	0.75 ± 0.26 de	0.25 ± 0.04 d	0.83 ± 0.45 a
3°C	120	5.11 ± 0.02 c	2.18 ± 0.54 cd	0.65 ± 0.10 ef	0.41 ± 0.02 bc	0.41 ± 0.02 bc
8°C		4.48 ± 0.47 d	2.10 ± 0.44 cd	1.86 ± 0.42 a	0.39 ± 0.11 bc	0.41 ± 0.08 bc
Control		3.34 ± 0.28 f	1.80 ± 0.17 def	1.11 ± 0.36 c	0.20 ± 0.06 d	0.66 ± 0.22 ab
3°C	180	4.66 ± 0.37 d	1.53 ± 0.28 ef	1.43 ± 0.23 bc	0.44 ± 0.08 ab	0.85 ± 0.01 a
8°C		4.08 ± 0.01 e	1.41 ± 0.03 f	1.19 ± 0.11 c	0.34 ± 0.04 c	0.77 ± 0.22 ab
Control		2.73 ± 0.02 g	0.76 ± 0.15 g	0.72 ± 0.16 e	0.22 ± 0.05 d	0.42 ± 0.18 bc

[a] Data are the mean±SE. Different letters in the same column indicate significant difference at P≤ 0.05 probability.

in the control fruits with 1.17±0.35 mg 100 g^{-1} fw (Table 1). Similar trend in TC content was found in shelf life. It is known that TC content is affected by pre- and post-harvest factors (Provesi and Amante, 2015) such as storage and handling conditions. Çetin (2015) reported that TC content decreased in fresh-cut pumpkins as the storage period extended, which confirmed the results of the present study.

Sugar Content

The initial sucrose, glucose, and fructose contents of the pumpkins were 1.76±0.02, 0.50±0.10 and 0.84±0.03 g 100 g^{-1} fw, respectively (Table 1). At the end of storage period, sucrose content showed fluctuation during the storage and shelf life, however, it decreased compared to initial value.

[DOI: 10.22034/JAST.26.1.85]

Table 3. The decay rate, decay severity, and chilling injury of pumpkins stored at different storage temperatures and at the end of the shelf life. [a]

Treatments	Storage times (Days)	Decay rate (%)	Analysis Decay severity	Chilling injury
Cold storage				
3°C	60	0.0 ± 0.0 e*	0.0 ± 0.0 f	0.0 ± 0.0 c
8°C		0.0 ± 0.0 e	0.0 ± 0.0 f	0.0 ± 0.0 c
Control		2.8 ± 1.2 e	0.3 ± 0.6 ef	0.0 ± 0.0 c
3°C	120	13.9 ± 4.8 d	1.7 ± 0.6 cd	0.7 ± 0.6 b
8°C		11.1 ± 4.8 d	1.0 ± 0.0 de	0.0 ± 0.0 c
Control		25.0 ± 0.0 c	1.0 ± 0.0 de	0.0 ± 0.0 c
3°C	180	36.1 ± 4.8 b	2.7 ± 0.6 b	1.3 ± 0.6 a
8°C		22.2 ± 4.8 c	2.3 ± 0.6 bc	0.0 ± 0.0 c
Control		43.9 ± 5.4 a	5.3 ± 0.6 a	0.0 ± 0.0 c
Shelf life				
3°C	60+7	0.0 ± 0.0 f	0.0 ± 0.0 e	0.0 ± 0.0 c
8°C		0.0 ± 0.0 f	0.0 ± 0.0 e	0.0 ± 0.0 c
Control		5.5 ± 2.4 e	0.7 ± 0.6 d	0.0 ± 0.0 c
3°C	120+7	16.7 ± 0.00 d	2.0 ± 0.0 c	1.3 ± 0.6 b
8°C		13.9 ± 4.8 d	1.0 ± 0.0 d	0.0 ± 0.0 c
Control		27.8 ± 4.8 c	2.0 ± 0.0 c	0.0 ± 0.0 c
3°C	180+7	41.7 ± 0.00 b	3.0 ± 0.0 b	2.0 ± 0.0 a
8°C		25.0 ± 0.00 c	2.3 ± 0.6 c	0.3 ± 0.6 c
Control		52.8 ± 5.1 a	5.7 ± 0.6 a	0.0 ± 0.0 c

[a] (a-f) Data are the mean ± SE. Different letters in the same column indicate significant difference at $P \leq 0.05$ probability.

Additionally, there were no significant differences between sucrose content of pumpkins stored in all storage temperatures after 180 days (Table 1). On the contrary, sucrose content of the control fruit was lower than fruits stored at 3 and 8°C in shelf life (Table 2). On the other hand, glucose content was higher in all storage temperatures as compared to the initial value. However, glucose content of fruits stored at 3°C was higher than those stored at 8°C and control after 180 days storage (Table 1). Similarly, fruit stored at 3°C had higher glucose content compared to others at 180+7 day (Table 2). While fructose content of the fruits was almost the same in fruits stored at 8 °C compared to the initial value, at the end of the storage period, it decreased as compared to other storage temperatures (Table 1). Additionally, fructose content of fruits stored at 3 and 8°C under shelf life was found to be higher than the control (Table 2). Corrigan *et al*. (2000) claimed that sucrose proportion was higher in pumpkin relative to fructose and glucose, and sucrose proportion generally decreased with storage. They also highlighted that glucose and fructose contents can fluctuate with storage depending on varieties having low and high starch content. Glucose, fructose, and especially sucrose are the dominant sugars in pumpkins, and the sugar contents can fluctuate during storage, especially at higher temperatures (Kami *et al*., 2011). In the present study, considering all sugar components, 8°C was more suitable in terms of both initial value and values determined in other storage temperatures at the end of storage period.

Decay Incidence, Decay Index and Chilling Injury

Decay incidence, decay index, and chilling injury progressively increased with advancement in storage period irrespective

[DOI: 10.22034/JAST.26.1.85]

of storage temperatures, and this increase was more obvious in shelf life (Table 3). During the first 60 days of storage, no decay occurred in the fruits stored at 3 and 8°C, while at the end of 180 days of storage, the lowest decay incidence was found in fruits stored at 8°C (22.2±4.8%) with the highest in the control (43.9±5.4%) (Table 3). There were no statistical differences between the treatments and decay index on day 60 and 120 of storage, however, decay index reached 5.3±0.6 in the control stored at 180 days (Table 3). At the end of 180+7 days of storage, while the highest decay index was in the control (5.7±0.6), the lowest was in fruits stored at 8°C (2.3±0.6) (Table 3). In the present study, it was noticed that the fruits stored at 3°C showed CI symptoms after 120 and 180 days storage and the CI indices at these storage periods were 0.7±0.6 and 1.3±0.6, respectively (Table 3). Similar observations were recorded with respect to shelf life of fruits at 20°C. Winter squash stored at 5°C showed chilling injury after the 2nd and 4th month cold storage (Gibe and Lee, 2008).

Pathogens such as *Fusarium* spp., *Pythium* spp., *Colletotrichum* spp. and *Rhizopus* spp. caused decay throughout the storage of pumpkins (Cantwell and Suslow, 2014). In fresh cut pumpkins, microorganism causing decay increased with storage time under different modified atmospheric conditions (Çetin, 2015; Habibunnisa *et al*., 2001). In the present study, the pumpkins stored at ambient temperature had very high level of decay and incidence. Therefore, storage at low temperature is the most effective method to control microorganism activities causing decay in most fruits and vegetables. Additionally, pumpkins were sensitive to low temperature depending on cultivars, and pre and postharvest factors. Therefore, the appropriate temperature for storage must be selected to balance both storage period and temperature.

CONCLUSIONS

This study showed that storing pumpkins at ambient temperature negatively affects their biochemical properties and low temperature was helpful to reduce the rate of degradation of bio-active compounds, but caused chilling injury triggering the decay. The optimum temperature to protect fruit firmness was determined as 8°C as compared to 3°C and the control. Therefore, 8°C was the most suitable temperature in minimizing chilling injury and decay to protect biochemical properties of pumpkins. To sum up, pumpkin fruits are safely stored at 8°C for 180 days without affecting the quality. These results can be beneficial to obtain optimal fruit quality management in the pumpkin industry, especially for traders and consumers in a long-term storage.

ACKNOWLEDEGEMNTS

The work was supported by Turkish Science and Technology Research Council (TUBITAK), Grant Number 118O151.

REFERENCES

1. Amodio, M. L., Rinaldi, R. and Colelli, G. 2010. Extending Shelf Life of Fresh-cut Pumpkin (*Cucurbita maxima*): Effect of Pre-treatments and Storage Conditions. *Acta Hortic.,* **876:** 333-340.
2. Arvayo-Ortiz, R. M., Garza-Ortega, S. and Yahia, E. M. 1994. Postharvest Response of Winter Squash to Hot-Water Treatment, Temperature, and Length of Storage. *HortTechnology,* **4:** 253-255.
3. Balkaya, A., Ozbakir, M. and Karaagaç, O. 2010. Evaluation of Variation and Fruit Characterization of Pumpkin (*Cucurbita moschata* Duch.) Populations Collected from Black Sea Region. *J. Agric. Sci.,* **16:** 17-25.
4. Biesiada, A., Nawirska, A., Kucharska, A. and Sokół-Łętowska, A. 2011. Chemical Composition of Pumpkin Fruit Depending on

[DOI: 10.22034/JAST.26.1.85]

Cultivar and Storage. *Ecol. Chem. Eng. A,* **18:** 9-18.
5. Bourne, M. C. 2004. Selection and Use of Postharvest Technologies as a Component of the Food Chain. *J. Food Sci.,* **69:** 43-46.
6. Cantwell, M. and Suslow, T. V. 2014. *Pumpkin and Winter Squash*. Postharvest Center, University of California. Available at: http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=28&ds=799.
7. Cemeroğlu, B. 2007. *Food Analysis*. The Association of Food Technology Press, Ankara, Turkey, PP. 185-190.
8. Corrigan, V. K., Irving, D.E. and Potter, J. F. 2000. Sugars and Sweetness in Buttercup Squash. *Food Qual. Prefer.,* **11:** 313-322.
9. Çetin, R. Ü. 2015. Quality Changes and Shelf-life Determination of Modified Atmosphere Packaged Fresh-cut Pumpkin Slices. MSc Dissertation, University of Süleyman Demirel, Turkey.
10. Dinu, M., Soare, R., Hoza, G. and Becherescu, A. D. 2016. Biochemical Composition of Some Local Pumpkin Population. *Agric. Agric. Sci. Procedia,* **10:** 185-191
11. Echeverria, E. and Valich, J. 1989. Enzymes of Sugar and Acid Metabolism in Stored 'Valencia' Oranges. J. *Am. Soc. Hortic. Sci.,* **114:** 445-449.
12. Fu, C. L., Shi, H. and Li, Q. H. 2006. A Review on Pharmacological Activities and Utilization Technologies of Pumpkin. *Plant Foods Hum. Nutr.,* **61:** 73-80.
13. Gajewski, M., Radzanowska, J., Danilcenko, H., Jariene, E. and Cerniauskiene, J. 2008. Quality of Pumpkin Cultivars in Relation to Sensory Characteristics. *Not. Bot. Horti. Agrobo Cluj-Napoca* **36:** 73-79.
14. Garcia-Pastor, M. E., Serrano, M., Guillen, F., Zapata, P. J. and Valero, D. 2020. Preharvest or a Combination of Preharvest and Postharvest Treatments with Methyl Jasmonate Reduced Chilling Injury, by Maintaining Higher Unsaturated Fatty Acids, and Increased Aril Colour and Phenolics Content in Pomegranate. *Postharvest Biol. Technol.,* **167:** 111226.
15. Gibe, A. J. G. and Lee, J. W. 2008. Incidence of Chilling Injury in Two Varieties of Winter Squash (*Cucurbita maxima* Duch.) at Low Temperature Storage. *Hortic. Environ. Biotechnol.,* **49:** 104-108.
16. Habibunnisa Baskaran, R., Prasad, R. and Shivaiah, K. M. 2001. Storage Behaviour of Minimally Processed Pumpkin (*Cucurbita maxima*) under Modified Atmosphere Packaging Conditions. *Eur. Food Res. Technol.,* **212:** 165-169.
17. Holb, I. J. and Schnabel, G. 2007. Differential Effect of Triazoles on Mycelial Growth and Disease Measurements of *Monilinia fructicola* Isolates with Reduced Sensitivity to DMI fungicides. *Crop Protec*., **26(5):** 753-759.
18. Hong, J. H. and Gross, K. C. 2001. Maintaining Quality of Fresh-cut Tomato Slices through Modified Atmosphere Packaging and Low Temperature Storage. *J. Food Sci.,* **66:** 960-965.
19. Huynh, A. T. and Nguyen, H. V. H. 2020. Effects of Ethanol and Chitosan Treatments on the Quality and Storage Life of Minimally Processed Pumpkin (*Cucurbita moschata* Duch). *J. Hortic. Postharvest Res.* **3:** 221-234.
20. Junqueira, J. R. D., Correa, J. L. G. and Ernesto, D. B. 2017. Microwave, Convective, and Intermittent Microwave-Convective Drying of Pulsed Vacuum Osmodehydrated Pumpkin Slices. *J. Food Process. Preserv.,* **41:** e13250.
21. Kami, D., Muro, T. and Sugiyama, K. 2011. Changes in Starch and Soluble Sugar Concentrations in Winter Squash Mesocarp During Storage at Different Temperatures. *Sci. Hortic.,* **127:** 444-446.
22. Karhan, M., Aksu, M., Tetik, N. and Turhan, I. 2004. Kinetic Modeling of Anaerobic Thermal Degradation of Ascorbic Acid in Rose Hip (*Rosa canina* L) Pulp. *J. Food Qual.,* **27:** 311-319.
23. Lee, S. K. and Kader, A. A. 2000. Preharvest and Postharvest Factors Influencing Vitamin C Content of Horticultural Crops. *Postharvest Biol. Technol.,* **20:** 207-220.
24. Lefebvre, D., Gabriel, V., Vayssier, Y., and Fontagne-Faucher, C. 2002. Simultaneous HPLC Determination of Sugars, Organic Acids and Ethanol in Sourdough Process. *LWT-Food Sci. Technol.,* **35:** 407-414.

[DOI: 10.22034/JAST.26.1.85]

25. Marangoni, A. G., Jackman, R. L. and Stanley, D. W. 1995. Chilling-Associated Softening of Tomato Fruit is Related to Increased Pectinmethylesterase Activity. *J. Food Sci.*, **60:** 1277-1281.
26. Nanda, S., Rao, D. V. S. and Krishnamurthy, S. 2001. Effects of Shrink Film Wrapping and Storage Temperature on the Shelf Life and Quality of Pomegranate Fruits cv. *Ganesh. Postharvest Biol. Technol.,* **22:** 61-69.
27. Provesi, J. G. and Amante, E. R. 2015. Carotenoids in Pumpkin and Impact of Processing Treatments and Storage. In: "*Processing and Impact on Active Components in Food"*, Academic Press, UK, PP. 71-80.
28. Provesi, J. G., Dias, C. O. and Amante, E. R. 2011. Changes in Carotenoids During Processing and Storage of Pumpkin Puree. *Food Chem.,* **128:** 195-202.
29. Rahman, M., Miaruddin, M., Khan, M., Masud, M. and Begum, M. 2013. Effect of Storage Periods on Postharvest Quality of Pumpkin. *Bangladesh J. Agric. Res*., **38:** 247-255.
30. Sharma, S. and Ramana Rao, T. V. 2013. Nutritional Quality Characteristics of Pumpkin Fruit as Revealed by its Biochemical Analysis. *Int. Food Res. J.,* **20:** 2309-2316.
31. Survase, S. S., Garande, V. K., Pawar R. D. and Sonawane, P. N. 2021. Effect of Different Edible Coatings on Physico-Chemical Composition and Sensorial Qualities of Fresh Cut Red Pumpkin. *Pharma. Innov. J*., **10(12):** 2535-2540.
32. Yahia, E. M., Celis, M. E. M. and Svendsen, M. 2018. The Contribution of Fruit and Vegetable Consumption to Human Health. In: *"Fruit and Vegetable Phytochemicals: Chemistry and Human Health"*, Wiley & Sons, USA, PP. 3-52.
33. Yuan, L., Bi, Y., Ge, Y. H., Wang, Y., Liu, Y. Y. and Li, G. L. 2013. Postharvest Hot Water Dipping Reduces Decay by Inducing Disease Resistance and Maintaining Firmness in Muskmelon (*Cucumis melo* L.) Fruit. *Sci. Hortic.*, **161**: 101-110.
34. Zhang, F., Jiang, Z. and Zhang, E. 2000. Pumpkin Function Properties and Application in Food Industry. *Sci. Technol. Food Ind.,* **21:** 62-64.
35. Zinash, A. and Woldetsadik, K. 2013. Effect of Accessions on the Chemical Quality of Fresh Pumpkin. *Afr. J. Biotechnol*., **12:** 7092-7098.

تغییرات در ترکیبات زیست‌فعال، نرخ پوسیدگی و سرمازدگی کدو تنبل انبار شده در دماهای مختلف

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چکیده

اثر دمای انبار بر ترکیبات زیست‌فعال، پوسیدگی، و سرمازدگی کدو تنبل در طول دوره نگهداری در سرما و ماندگاری در انبار مورد بررسی قرار گرفت. در این پژوهش، برای تعیین ماندگاری در انبار، کدو ها در دمای ۳ درجه سانتی گراد، ۸ درجه سانتی گراد و دمای محیط (شاهد) به مدت ۱۸۰ روز، و پس از آن به مدت ۷ روز در دمای ۲۰ درجه سانتی گراد نگهداری شد. کمترین کاهش وزن در کدوهای انبارشده در دمای ۳ درجه

[DOI: 10.22034/JAST.26.1.85]

سانتی‌گراد در طول نگهداری سرد و بیشترین سفتی گوشت در کدوهای انبارشده در دمای ۸ درجه سانتی‌گراد مشاهده شد. در کدوهای انبارشده در دمای ۳ درجه سانتی‌گراد، کل مواد جامد محلول، اسید L-آسکوربیک و گلوکزدر مقایسه با سایر دماهای انبارداری، بیشتر بود.بیشترین میزان کاروتنوئید کل و کمترین میزان پوسیدگی در میوه های نگهداری شده در دمای ۳ و ۸ درجه سانتی گراد ثبت شد. میوه های نگهداری شده در دمای ۳ درجه سانتی گراد پارامترهای کیفی بهتری را در مقایسه با سایر دماهای مورد مطالعه نشان دادند. اگرچه دمای ۳ درجه سانتی گراد برای محافظت از ترکیب بیوشیمیایی میوه های کدو تنبل بهتر بود، اما میزان پوسیدگی در این دما به دلیل سرمازدگی افزایش یافت. نتیجه گیری می شود که دمای نگهداری ۸ درجه سانتی گراد برای حفظ کیفیت میوه و محتویات بیوشیمیایی و جلوگیری از پوسیدگی در طول نگهداری طولانی مدت کدو تنبل دمای بهینه بود.

[DOI: 10.22034/JAST.26.1.85]