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RESEARCH ARTICLE

# Combined Effects of Calcium Ascorbate Treatment and Modified Atmosphere Packaging to Improve Quality Retention of Fresh-Cut Cantaloupes

**Joongmin Shin***
California Polytechnic State University

**Kevin Mis Solval**
University of Georgia

**Bob Xiang**
3SunTree LLC

**Youn Suk Lee**
Yonsei University

## ABSTRACT

*The impact of passive modified atmosphere packaging technique (MP) and calcium ascorbate (CA) on the extension of freshness and shelf life in fresh-cut cantaloupe was studied at two storage temperatures (4 and 10°C). Fresh cantaloupes were cut into uniform size cubes (25.4 mm x 25.4mm x 25.4mm). Then, half of the fresh cut cubes was dipped into the treatment solution, and the others were not. Clamshell tray with snap-on lid (control) and micro-perforated sealable lid (MP) was used as the fresh cut fruits packaging. Fresh cut cantaloupes in CA and MP combination (CA-MP) observed the highest quality preservation among the other samples. The maximum inhibition of mold and yeast was up to 3.0 $_{log}10$ CFU/g, comparing to control. CA-MP also maintained higher physiochemical quality parameters, including color, texture, L-ascorbic acid and total soluble solid contents. The results indicated that the modified atmosphere and calcium ascorbate combination treatment is a potential application to extend the shelf life of fresh-cut cantaloupes.*

## KEY WORDS

*Cantaloupe, MAP, calcium ascorbate, fresh cut fruit*

***Joongmin Shin**
*Corresponding Author*
jshin20@calpoly.edu

## INTRODUCTION

The consumption of minimally processed fresh-cut cantaloupes (Cucumis melo) is rapidly growing in the retail and food service industries due to the increasing market for convenient and ready-to-eat food [1]. Fresh cut cantaloupe, like other fresh-cut fruits, is a highly perishable commodity. Retail stores rarely sell the product for more than three days [2]. The mechanical cutting procedures, including washing and peeling, may increase metabolic activities and biochemical deterioration in fresh-cut fruits including browning, softening, decay and off-flavor development [3]. However, consumers want to purchase fresh cut fruits without any defects at a grocery store [4]. Thus, one of the on-going challenges is to delay browning and extend the shelf life of the perishable products such as fresh cut fruits.

A most common type of packaging method for fresh-cut fruits include clamshell and snap on lid. These rigid trays protect the products during handling and storage. However, gas transmission of these containers is not engineered or controlled. If the fruits are packaged with an airtight lid, they start anaerobic respiration which produced carbon dioxide and other fermentation by-product. Oppositely, high permeable rigid tray with non-airtight lid has also had a limited shelf life because of its high respiration rate and rapid maturation. The micro-perforation on film, called passive modified atmosphere packaging (MAP), is a well-known technology to generate an ideal atmosphere for fresh produces (Gonzalez-Buesa et al., 2009; Philips, 1996). An ideal package maintains the optimum level of $O_2$ and $CO_2$ in the package by matching the $O_2$ and $CO_2$ transmission rate through the package to the respiration rate of the produce at the desired storage temperature [4, 5]. Many studies have already reported that modified atmospheres (using the micro-perforated film) are generally useful to reduce microbial growth, respiration rate, and other quality deteriorations [6, 7]. However, the use of MAP alone has still shown some limitation for some fruits such as cantaloupes, pineapples, and apples. The problem of enzymatic browning and softening is not eliminated by MAP [8].

Several enzyme inhibitors and antioxidants were applied to reduce browning and decay of fresh fruits and vegetables. The chemical compounds, including ascorbic acid, isoascorbic acid, potassium sorbate, and calcium chloride, were effective in reducing browning and decay of many fresh-cut fruits and vegetables [9]. Ascorbate is one of the common antibrowning agents used for fresh-cut fruits and is recognized as a GRAS substance by the U.S. Food and Drug Administration (FDA) for its use to prevent and control polyphenol oxidase (PPO) enzyme which is the critical enzyme in enzymatic browning after fruits cutting operation [10]. Some studies have shown the effect to maintain the quality of fresh-cut fruits when ascorbate is applied with calcium salts. Calcium provides rigidity to the cell wall and maintains the texture of products, and ascorbate is a well-known antioxidant. Thus, a combination of ascorbate and calcium has been applied to fresh produce such as apple, pear, etc., to prevent enzymatic browning of fruits and cell and membrane breakdown [11]. However, this type of treatment can lose its effectiveness if ascorbate is completely oxidized and become dehydroascorbic acid. Then, browning of the fresh fruits occurs [12]. Also, Saba [9] reported that ascorbate could even cause some oxidative damage in fresh-cut apples. The controlled concentration oxygen under MAP may delay such oxidative damage of anti-browning agent and results in the better quality maintenance of fresh-cut cantaloupes, but the effects of such combined treatments for the fresh cut cantaloupes have rarely reported under our best knowledge. The purpose of this study was to evaluate the effectiveness of calcium ascorbate in maintaining the quality of fresh-cut cantaloupes, in conjunction with modified atmosphere packaging. The effects on reduction of browning, texture changes, respiration, and other quality attributes as well as microbial decay were studied at two storage temperatures (10 and 4°C).

## MATERIAL

Cantaloupes (*Cucumis melo* L.) without any visual defects were purchased from a wholesale market and stored at 4°C for one day before the experiment. The cantaloupes were purchased when they just delivered from a local farm. They were harvested during July and August. Cantaloupes were washed 200 ppm (200 µL/L water) of sodium hypochlorite solution (pH 6.5) for 5 min. The sanitized cantaloupes were peeled, halved, and cut into 25.4 mm square cubes using cookie cutter and knife. Then the cubes were rinsed with 100 ppm (100 µL/L water) of sodium hypochlorite solution for 2 min and drained for 30 min. All utensils (knives, cutting boards, and other equipment which come into contact with the fruits were sanitized by immersion in 1000 ppm (1000 µL/L water) of sodium hypochlorite solution for 1 hr before cutting.

## METHOD

### Calcium ascorbate (CA) treatment

Calcium ascorbate (NatureSeal™, Montrose-Hauser Co., Westport, CT, USA) 77g measured and slowly added to 3.8 liters of distilled water (at ambient temperature). The prepared CA mixed solution was transferred to a low-temperature food processing room (at 4°C) for dipping and packaging process. The fresh-cut cantaloupes were dipped into the solution for 2 minutes. Then, the cantaloupes were dipped again to ensure all cut surfaces were coated with the solution. All treated fruits were then drained on a stainless steel mesh for 30 min.

### Packaging

For control package, approximately 300g (about 18 cubes) of the prepared cantaloupe cubes, as is discussed above, were filled into PET clamshell (Genpack, Glens Falls, NY, USA) which is commonly used a type of fresh cut fruits packaging. The size of the clamshell was 145 mm x 170 mm x 45 mm. For modified atmosphere packaging, the cubes were placed into PP/EVOH/PP trays (133.35 mm x 190.5 mm x 38.1 mm, Cryovac, SC, USA) and sealed with 0.0381mm of laser micro-perforation film (Dupont, Wilmington, DE, USA). The oxygen permeability of the film was 2.09 x $10^{-6}$ cc.µm/$m^2$.s.Pa (with 7 holes) at 23°C. Modified atmosphere packaging was done using a T-200 tray sealer (Multivac, Inc, Kansas, MO) after flushing the container with medical grade air (21% $O_2$ and 0% $CO_2$). Overall, 4 different packages were prepared as follows:

- CON: untreated fresh-cut cantaloupes in clamshell.
- CA: calcium ascorbate treated fresh-cut cantaloupes in clamshell.
- MP: untreated fresh-cut cantaloupes in the MAP.
- CA-MP: calcium ascorbate treated fresh-cut cantaloupes in the MAP.

4 and 10°C were selected in this study as storage temperatures. The recommended storage temperature for fresh-cut produce is below 4°C since the low temperature reduced the metabolic respiration rate of the product significantly [13]. Bai [1] also reported a longer shelf life of fresh-cut produces stored at 4-5°C than at 10°C. 10°C was also selected because fresh-cut fruits are usually stored in open display chiller or even placed on ice-cubes at a retail store. Total storage periods were 18 days for 4°C and 12 days for 10°C. Measurements of all attributes were done every 3-4 day until the end of storage.

**Headspace analysis**

The headspace compositions ($O_2$ and $CO_2$) in packages (CON, CA, MP, CA-MP) were monitored using PAC CHECK® 650 headspace analyzer (Mocon, Minneapolis, MN, USA) during storage. Packages were removed from storage, and an adhesive septum (Mocon, Minneapolis, MN, USA) adhered to the lid surface. 10 ml of headspace in packaging was withdrawn using a syringe and injected into the headspace analyzer.

**Respiration rate**

The difference in respiration rate was accessed using a titration method. 200g (around 12 cubes) of fresh-cut cantaloupes and 100 ml of 0.01N sodium hydroxide (NaOH) solution were placed into a 1000 ml airtight glass container. The lid equipped with a rubber septum and stored at 4 and 10°C. After 1 hour of storage, the released $CO_2$ in headspace was determined using titration method with 0.005 N NaOH solution. The respiration rate was expressed as mg $CO_2$/kg h.

**The contents of ascorbic acid (AA)**

For the evaluation of ascorbic acid, 15 g of cantaloupe (less than 1 cube) was blended and homogenized with cold 5% acetic acid solution and adjusted to a final volume of 50 ml. The homogenized sample was filtered through a 0.45μm syringe filter, and 10μl was injected for measurement of L-Ascorbic acid (AA). Waters 2690 HPLC (Waters, Milford, MA, USA) equipped with a photodiode array detector (PAD: Waters, Milford, MA, USA) at 254 nm. The column used in the test was a Phenomenex C-18 column (Phenomenex, Torrance, CA, USA). Milli-Q water with 10% acetic acid was used for the mobile phase, and the flow rate was 0.7 ml/min at 25°C. HPLC grade L-ascorbic acid (Sigma-Aldrich, St. Louis, MO, USA) used for standard calibration. Retention time was 4.1 min.

**Weight loss**

Weight loss of fresh-cut cantaloupes was determined by weighing the samples using balance (Pioneer™, Ohaus, Pine Brook, NJ, USA) at a specific time interval. The loss of weight was plotted as a function of time.

**Texture analysis**

Texture (Firmness) was determined using 5544 single column test system (Instron, Norwood, MA, USA) equipped with 0.01 kN (1kgf) load cell. The maximum force required to penetrate the fresh cut fruit was determined. A 6 mm of diameter flat head stainless steel cylindrical probe with 0.5 mm/min of loading speed was used.

**Surface color change**

The surface color (L*, a*,b*) of the fresh cantaloupe was periodically determined using the chromameter LABSCAN XE (Hunterlab, Reston, VA, USA). Each measurement was taken at three locations for each cantaloupe piece. The surface color changes were reported in CIELAB color scales (L* value is a degree of lightness of darkness, a* value is a degree of redness to greenness, and b* value is a degree of yellowness of blueness). Chroma (C*) and hue angle (H) can calculated as ($a^{*2} + b^{*2}$) and tan-1 (b*/a*), respectively.

**Total soluble solids (TSS)**

Total soluble solids (TSS) of fresh cantaloupe were measured using a digital Refractometer (AR 200, Reichert, Depew, NY, USA). Approximately 10 g of cantaloupes were cut into small pieces and ground. The TSS was determined in the juice of ground cantaloupe. Three measurements were tested on each sample, and the results were expressed in degrees Brix (°Bx).

### Microbial analysis

50 g (about 3 cubes) from each package were aseptically selected, sliced and transferred to a Whirl-Pack TM (Nabisco, Fort Atkinson, WI, USA) with 100 ml of sterile peptone water. The cantaloupes were homogenized for 1 minute in a stomacher. 1 ml of sample solution was placed onto the appropriate dried media after serial dilutions in peptone water. Yeasts and Molds were determined on Potato Dextrose Agar (Difco, Detroit, MI, USA) containing 20 ppm streptomycin (Sigma-Aldrich Co., St. Louis, MO) and 50 ppm ampicillin (Sigma-Aldrich). The plates were counted after 5 days of incubation at room temperature (23°C).

### Statistical analysis

Results were averaged, and means for the experiment including 2 temperatures (4 and 10°C), and 4 packages (CON, CA, MP, CA-MP) with 3 replicates. The data were analyzed using SPSS version 13 (SPSS, Chicago, Illinois, U.S.A.). Statistical analyses were performed using analysis of variance (ANOVA). Significant differences between means were determined by the Tukey's Honestly Significant Difference (HDS) test with a 5% significance level.

## RESULT AND DISCUSSION

### Packages atmosphere and respiration of fresh-cut cantaloupe

Many previous types of research already have shown the benefit to maintain fresh-cut cantaloupe quality with the elevated $CO_2$ atmosphere [14, 15]. Under a desirable container with the controlled gas transmission rate, $CO_2$ concentration increased gradually while $O_2$ concentration decreased during storage without causing anaerobic respiration. As is shown in Fig. 1, the micro-perforated packages (MP, MP-CA) maintained significantly higher $CO_2$ and lowered $O_2$ concentration than these of clamshell (CON, CA). Under MP and CA-MP at 4°C, the $O_2$ decreased to 14-15 % while $CO_2$ increased to 7-8% during the storage. At 10°C, O2 and $CO_2$ in MP and CA-MP were gradually changed to 6-7.5 and 10-12%. MP had the higher $CO_2$ and lowered $O_2$ concentration in both storage temperatures. It may be associated with the higher respiration activity of cantaloupes in MP (in Fig. 2). Generally, 2-6% $O_2$ and 7.5-15% Ca $O_2$ is considered an excellent atmosphere for fresh cantaloupes to maintain quality and reduce microbial growth [16, 17]. MP and CA-MP maintained their atmosphere close to the optimum level. Calcium ascorbate treatment did not show a significant effect on the atmosphere changes ($P>0.05$). Under the clamshell container, CON and CA had 18-21% $O_2$ and 0-3 % $CO_2$. The lower $CO_2$ and higher $O_2$ are mainly caused by the fast gas exchange due to the poor seal of the clamshell.

The determined respiration rate of cantaloupe in both temperatures showed the effect of modified atmosphere and calcium ascorbate treatment more clear (Fig. 2). Based on the measurements of $CO_2$ production, CON showed the highest respiration at all storage temperatures. At 4°C of storage temperature, the respiration rate in CON was gradually increased and reached up to 33 mg $CO_2$/Kg.h on day 15. MP and CA-MP maintained the similar respiration rate until day 9. Then, the respiration in MP gradually increased and kept the higher respiration than CA-MP until day 18. At 10 °C, the overall respiration rate in all packages was much higher that of 4 °C. Also, the effect of calcium ascorbate treatment and the MAP was more noticeable. On day 6, CON had a sharp respiration increase and reached the maximum level (115 mg $CO_2$/Kg.h) which is 45% higher than CA-MP. Both MP and CA-MP maintained the similar respiration during the storage. It was interesting that CA treatment was shown some effectiveness to suppress the cantaloupe's respiration rate ($P<0.05$). Limbo [18] reported that ascorbic acid or citric acid treatment affects enzymes of the oxidative phosphorylation pathway of fresh fruits, and it causes the decline of their respiration rate. Lu [19] also observed significantly lower oxygen consumption using the calcium ascorbate treatment on fresh-cut pear.

In our study, there was no significant package atmosphere difference between CON and CA (Fig.1.) Such a small respiration rate may not give a substantial impact on the atmosphere due to the high gas permeability of the clamshell. The results also clearly showed a positive effect of modified atmosphere packaging (MP and CA-MP) on the respiration rate of fresh-cut cantaloupes. It is well known that optimum modified atmosphere can minimize fresh fruit and vegetable respiration and senescence without causing suffocation and damage to metabolic activity that rapidly reduces their shelf life [10].

### L-ascorbic acid (AA) content

Initial AA contents in the fresh cut cantaloupe were 12.8 -13.2 mg/100 g (Fig. 3). The values corresponded to the range of initial AA contents in previous studies [20, 21]. The calcium ascorbate treated cantaloupes (CA and CA-MP) had the 9-12 % higher initial AA contents (14.1-14.9 mg/100 g) than untreated samples (CON and MP) due to the ingredient in the treatment. All treatments showed slow decreases in AA contents over the storage time. MP and CA-MP maintained significantly higher AA contents during storage at both 4 and 10°C ($P<0.05$). CON showed the most significant AA reduction. During the storage, only 57 and 33% of the initial AA contents were remained in CON at 4 and 10°C, respectively. CA-MP maintained 84 and 68 % of initial AA content at 4 and 10°C, respectively. AA contents in CA retained higher value than those in CON ($P<0.05$). At 10°C, CA maintained 8% higher values of AA contents compared to those in CON during the storage. The use of organic acids may work as reducing agents to delay/prevent enzymatic and chemical decomposition of cantaloupes [22].

### Total soluble solid contents (TSS) and weight loss

Total soluble solid contents of the fresh cut cantaloupes in all packages were gradually decreased during storage period due to post-harvest metabolism (Fig. 4). TSS profile of CA did not show any statistical different to CON at both storage temperatures. However, the fruits in a modified atmosphere (MP and CA-MP) showed the higher TSS values that these of CON and CA at 4°C. The CA-MP maintained the highest TSS values which is up to 1.5 Brix° higher than CON on day 18. No difference was observed among the samples at 10°C.

The loss of weight was significantly higher in the clamshells (CON and CA) than modified atmosphere packages (MP and CA-MP) at both storage temperatures (Fig. 4). At the end of the storage at each temperature, the loss of weight of package was around 4% in 4°C, and 7% in 10°C higher for clamshells (CON, CA) compared to modified atmosphere packages (MP, CA-MP). The loose sealing of the clamshell is probably caused loss of moisture and weight. Loss of weight in fresh fruit and vegetables is mainly due to the loss of water caused by transpiration and respiration processes. Ohta [23] reported that more than 5% of weight loss caused a reduction in retail value of vegetables and fruits. Baldwin [24] showed symptoms of freshness loss with 3-10% in fresh produce. Taking this into account, the physical barrier through a modified atmosphere package prevented moisture loss and therefore may retard dehydration and cantaloupe shriveling. The effect of CA treatments in weight loss reduction showed no significant difference ($P>0.05\%$).

#### Firmness

The firmness changes profile of the fresh-cut cantaloupe cubes in different packages in the two storage temperatures (4 and 10°C) are shown in Fig. 5. The initial firmness of the cantaloupe cubes was ranged from 10 to 12 N, and calcium ascorbate showed significant effectiveness to maintain cantaloupe's texture, especially at a lower temperature. At 4°C, CA and CA-MP maintained the higher firmness during the storage. Especially, firmness in CA-MP was approximately 3 times higher than CS on day 18. MP also showed some effect on the cantaloupe's firmness maintenance, but it was lower than CA. The overall loss of firmness in both CA and MP was 32 and 51% respectively during storage. At 10°C, due to the higher temperature, the firmness of cantaloupes in all packages was decreased rapidly and lost more than 50% during the storage. A significantly higher firmness in CA and CA-MP were observed until the 9th day, and CA became similar to those of CON and MP ($P>0.5$).

The loss of desirable texture in fresh-cut products is a significant problem. For fresh fruits, this is largely due to declining cell wall strength and intercellular adhesion by various reasons such as ripening, microbial growth, etc. In the case of fruits, wounding and water loss is essential contributors to textural deterioration. Previous researches have reported the effect of ascorbic acids and calcium treatment in firmness maintenance. Gonzalez-Aguilar [25] showed that 0.05M of ascorbic acid had effectiveness significantly to maintain the firmness of fresh cut pineapple. Rupasinghe [26] observed calcium treatment delayed firmness loss of fresh cut apple. They reported that ascorbic acid and calcium increase cell-to-cell adhesion and the stability of the cell wall of fresh fruits [27]. Our test results also showed that calcium ascorbate treatment was significant effective to maintain fresh cut.

The modified atmosphere also beneficial to delay firmness loss because it lowers the metabolism of cantaloupes and delays breakdown of tissue. MP was also shown some benefit to delaying firmness loss at a lower temperature (4°C), but it was lower than CA. Even if the level of firmness in CA is higher than MP, the sensorial mouth-feel in CA could be different to these results due to the higher weight loss as discussed previously (5.15% loss in CA) (Fig. 5). As a further study, sensory analysis is required to confirm the relationship between firmness and texture.

#### Color

The bright orange color cantaloupes cubes were initially observed at 61 with lightness (L*), 40.5 with chroma (C*), and 64.5 with hue angle (H), respectively (Fig. 6). Portela and Cantwell (2001) reported that the decrease in L* and C* are indicative of browning, translucent, and water-soaked appearance for the fresh cut fruits. Lamikanra [28] also mentioned oxidation of beta-carotene on fresh-cut cantaloupe is one of reason to decrease C* and H. At 10°C, the calcium ascorbate (CA) treatment showed significant effectiveness to maintain L*, C*, and H values while the beneficial effect on color retention was not very substantial with modified atmosphere. At the end of storage, CON had a dark orange color with high translucency appearance (in observation). MP showed slightly less L* decrease than CON. However, it was not statistically different to CON. CA and CA-MP had the higher L*, C*, and H values than samples without CA treatment but no difference was observed between them (CA and CA-MP). At 4°C, due to the lower storage temperature, overall color (L*, C* and H) at 4°C was decreased much slowly than 10°C. CON initially showed L*, C* and H reduction on day 9, then maintained the lower level than other packages statistically. Fruits treated with CA, MP, CA-MP showed a similar pattern of color changes during storage.

No significant difference was observed among these samples ($P$>0.05). The seldom color changes of cantaloupes at low temperature were also reported in another study [29]. Polyphenol oxidase (PPO) activity in cantaloupe, in which an enzyme primarily affected the browning reaction to fresh fruits, was very weak. Also, the level of phenolic compounds oxidation can be negligible at such a low storage temperature.

**Microbial population**

The initial population of yeasts and molds (PDA) were 1.9 log CFU/g. The population on PDA was increased in all samples as storage time increased, regardless of the treatment (Fig. 7), and CON showed the highest yeast and mold growth at both temperatures. At 4°C, the microbial population in CON was increased rapidly after 6 days and reached 6.8 log CFU/g at the end of storage. CA-MP maintained the lowest mold and yeast growth during the storage period, and the maximum difference between CON and CA-MP was 2.3 log CFU/g on day 18. There is no significant reduction between CON and CA-treated sample ($P$>0.05). The population in CA-MP was generally 0.1-1.0 log lower than these in MP ($P$<0.05). At 10°C, CON was also shown the highest and CA-MP was shown the lowest yeast and mold growth. CON was increased rapidly after 3 days and reached 7.2 log CFU/g on day 12. The maximum difference between CON and CA-MP was 3.0 log CFU/g on day 6. No significant difference was observed between CON and CA ($P$>0.05).

Under modified atmosphere packaging (MP, CA-MP), the mold and yeast growth was inhibited effectively due to the higher carbon dioxide in the packages. Enfors and Molin [30] reported that an elevated carbon dioxide in the modified atmosphere causes fungi and bacteriostatic characteristics against many spoilage organisms that can grow at refrigerated temperature. Calcium ascorbate is generally effective to reduce browning and to maintain firmness, but its inhibition effectiveness against mold and yeast growth on fresh fruit is seldom known. However, there is observed synergic mold and yeast inhibition when calcium ascorbate is combined with a modified atmosphere (CA-MP) at 4°C. Calcium ascorbate prevents softening of the cut surface where is allowed for microbial attack. Thus the firmer cell wall on the fresh fruits may delay the mold and yeast growth, especially with the MAP.

## CONCLUSION

Overall, the result indicated that the application of calcium ascorbate treatment plus a modified atmosphere (CA-MP) has the potential to prolong the shelf life of fresh-cut cantaloupe. The combination treatment effectively reduced mold and yeast growth, fruits deteriorative metabolism, nutritional loss, and surface browning. Especially, the quality maintenance effectiveness of calcium ascorbate and modified atmosphere combination was more substernal at lower storage temperature (4°C )than higher temperature (10°C).

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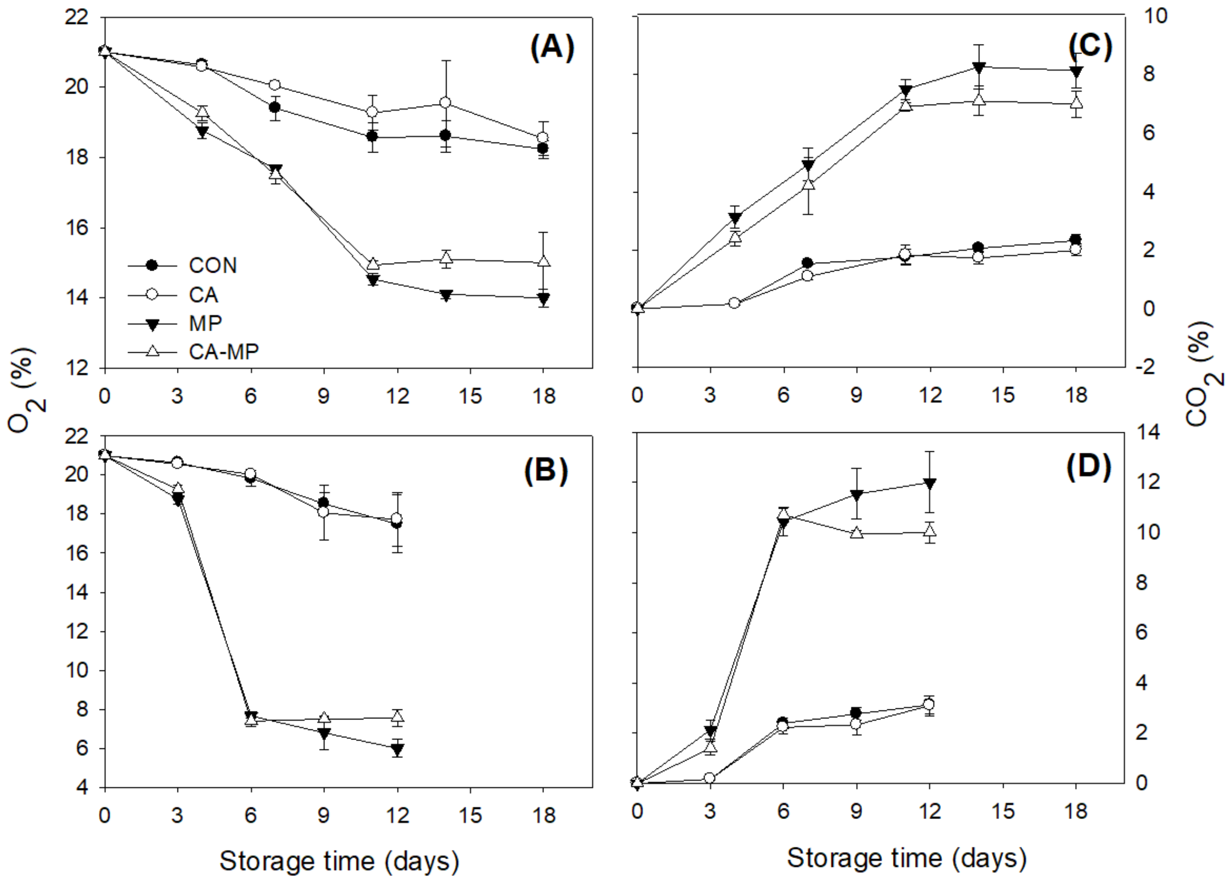


*Fig. 1: Evolution of $O^2$ and $CO^2$ concentration (%) in different packages of fresh-cut cantaloupe cubes over two temperatures (4 and 10°C). Error bars indicate standard deviations of the means. (A) O2@ 4° C, (B) O210°C, (C) CO2@4°C and (D) CO2@10°C.*

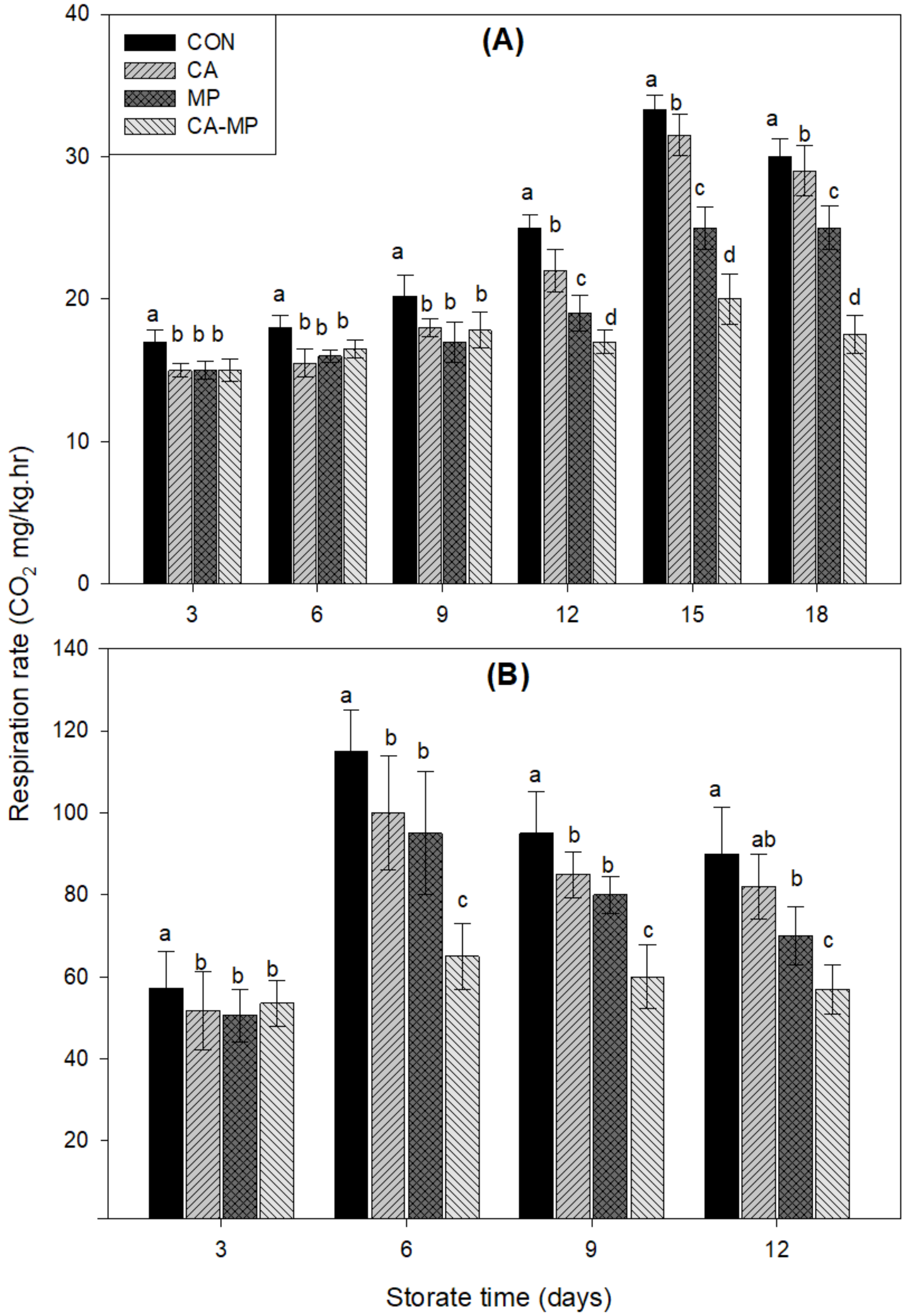


*Fig. 2: Respiration rate of fresh-cut cantaloupe cubes in different packages over two temperatures (4 and 10°C). Error bars indicate standard deviations of the means. The same letters within each group are not significantly different (P>0.05). (A) 4°C and (B) 10°C.*

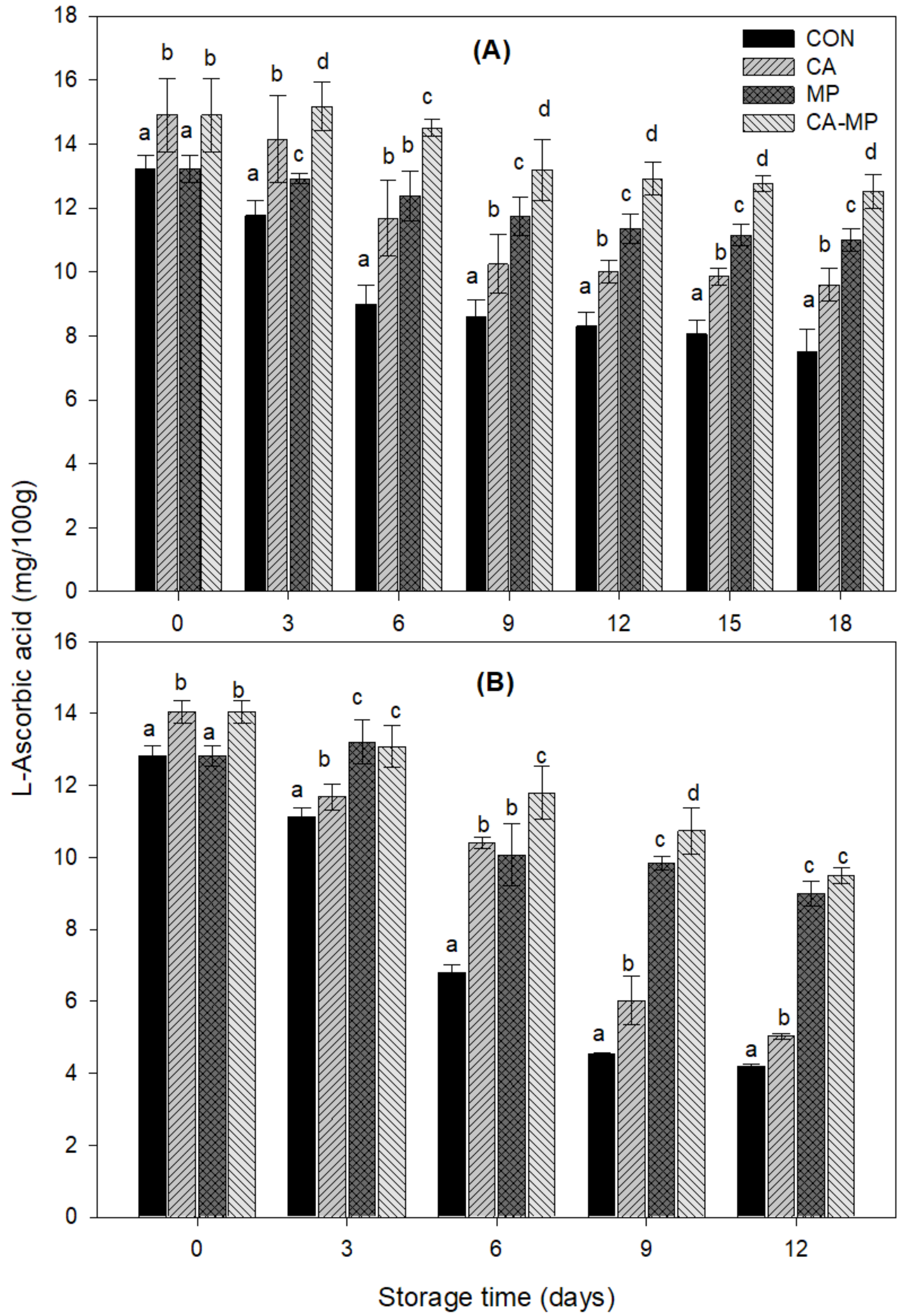


*Fig. 3: L-Ascorbic acid contents (mg/100g) of fresh-cut cantaloupe cubes in different packages over two temperatures (4 and 10°C). Error bars indicate standard deviations of the means. The same letters within each group are not significantly different (P>0.05). (A) 4°C and (B) 10°C.*

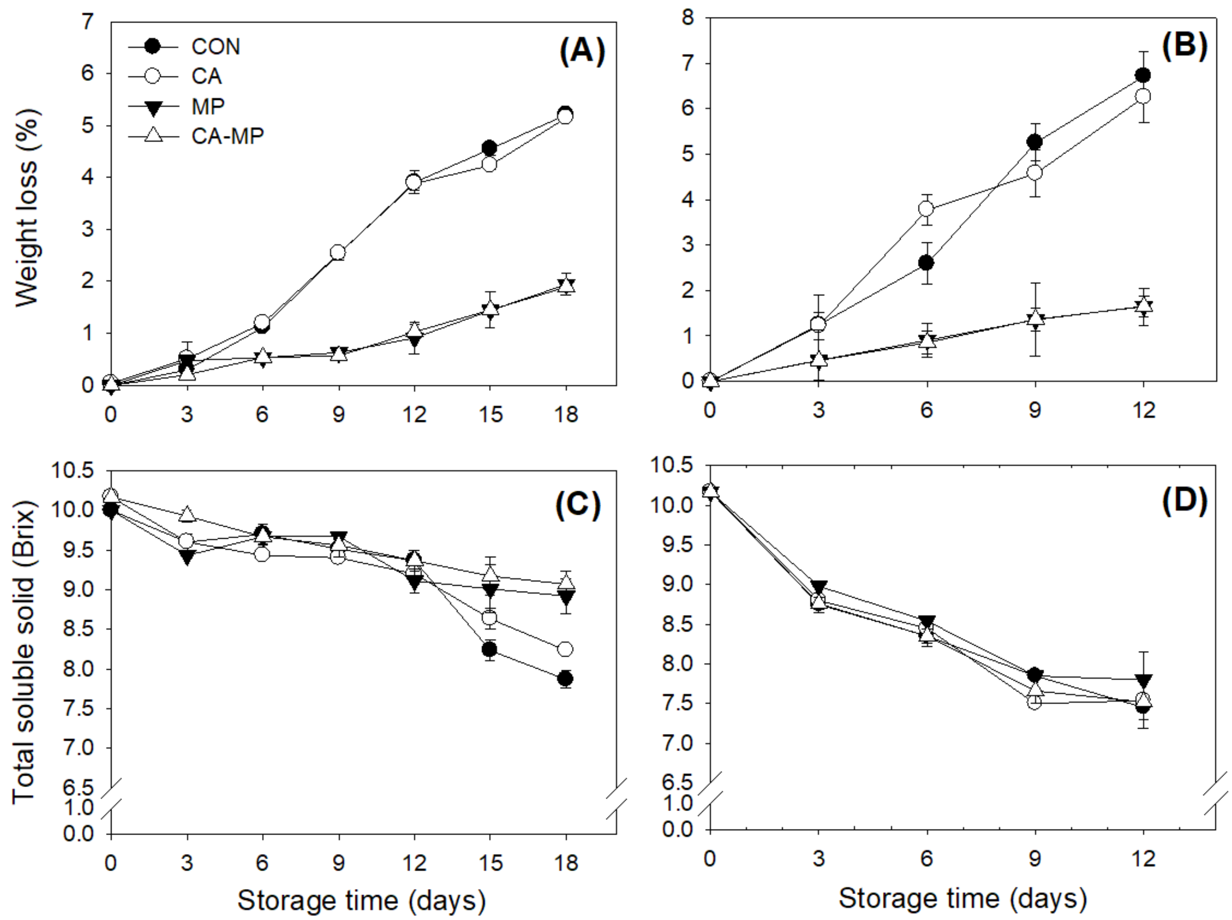


*Fig. 4: Effect of different packages on fresh cantaloupe cubes over two temperatures (4 and 10°C). (A) Weight loss at 4°C, (B) Weight loss at 10°C, (C) TSS at 4°C, (D) TSS at 10°C. Error bars indicate standard deviations of the means.*

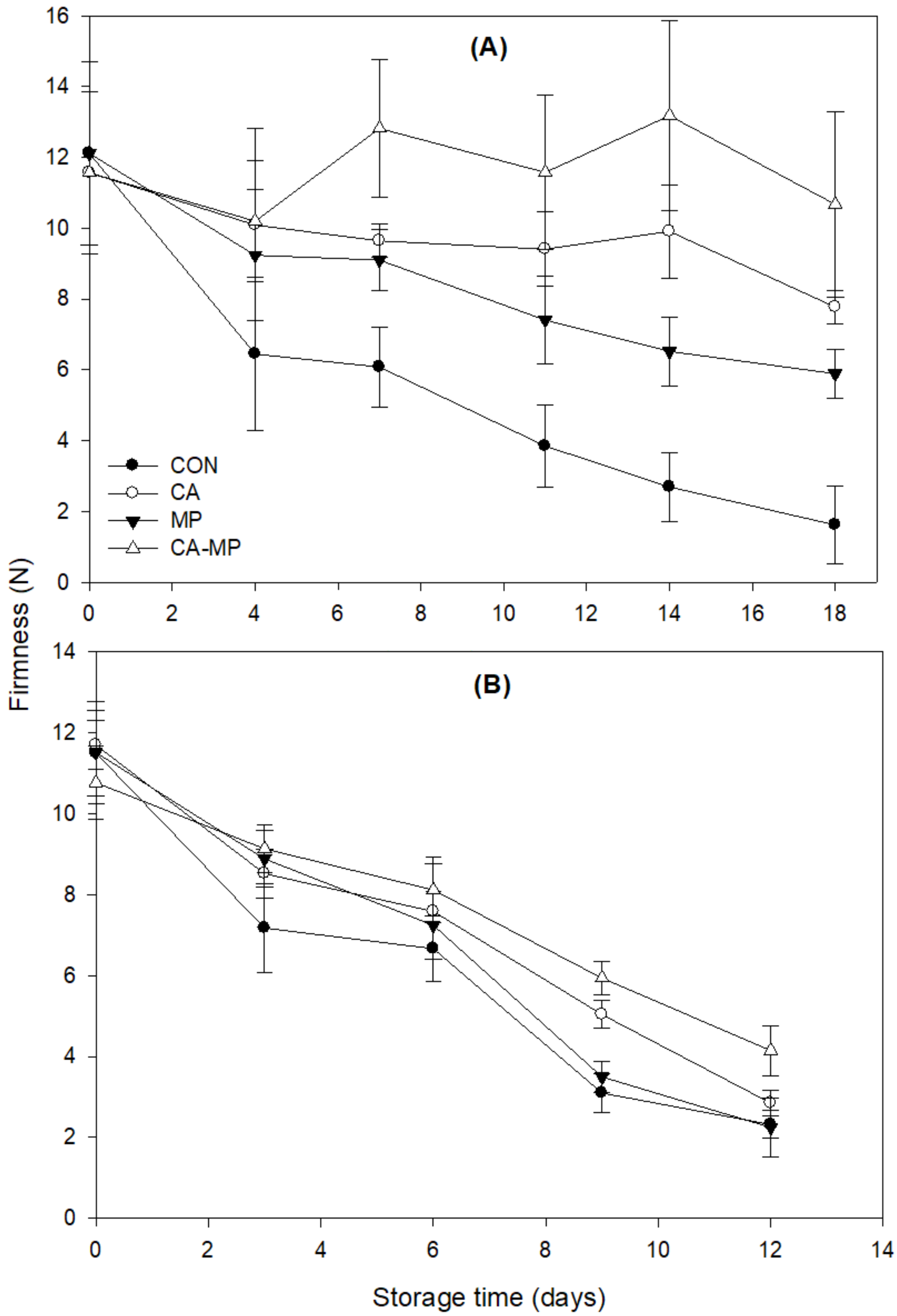


*Fig. 5: Firmness (N) of fresh-cut cantaloupe cubes in different packages over two temperatures (4 and 10°C). Error bars indicate standard deviations of the means. (A) 4°C and (B) 10°C.*

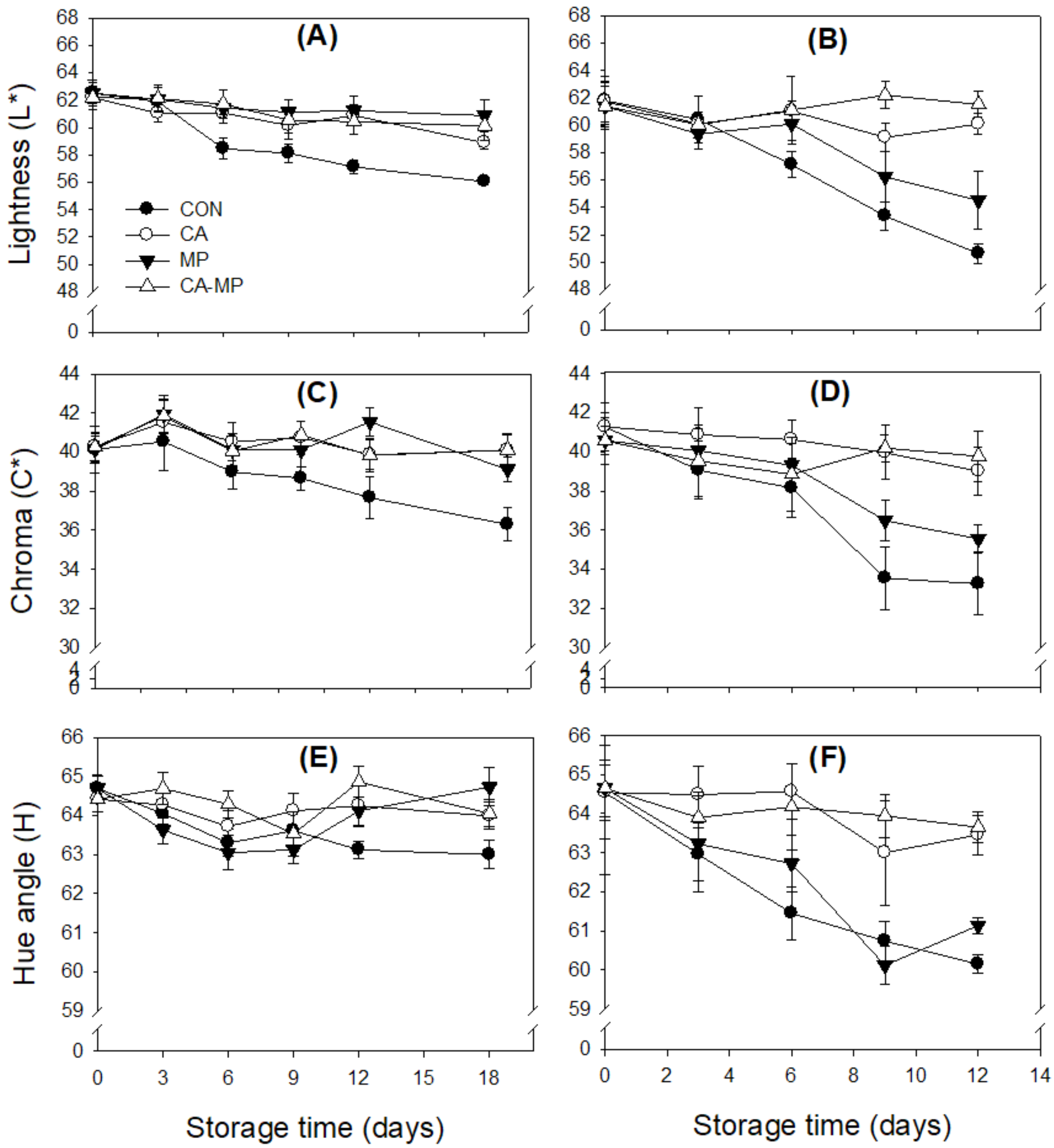


*Fig. 6: Color (L*, hue, chroma) on fresh cantaloupe cubes over two temperatures (4 and 10°C). (A) Lightness (L*) at 4°C, (B) Lightness (L*) at 10°C, (C) Chroma (C*) at 4°C, (D) Chroma (C*) at 10°C, (E) Hue angle (H) 4°C, (F) Hue angle (H) 10°C. Error bars indicate standard deviations of the means.*

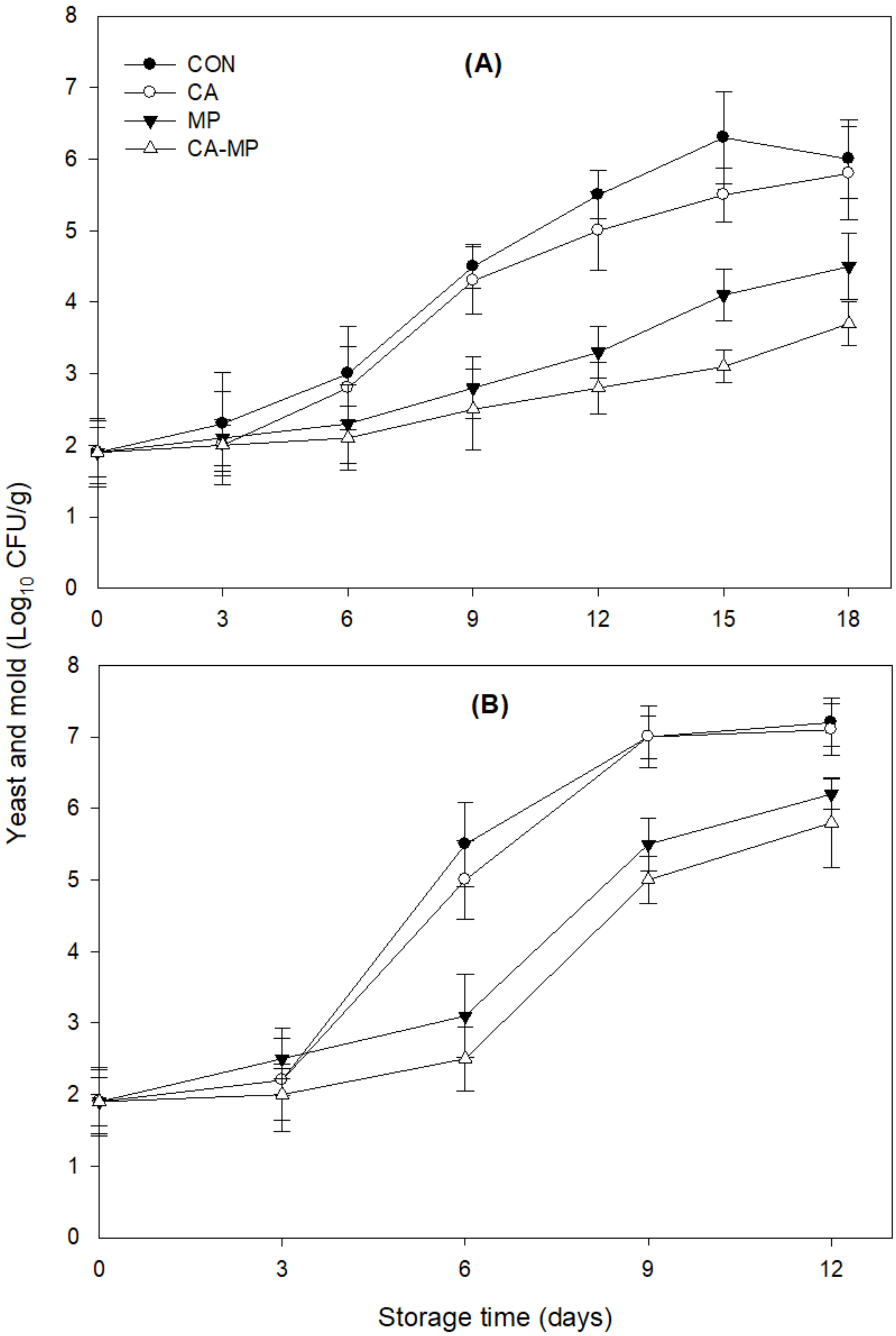


*Fig. 7: Yeast and mold population of fresh-cut cantaloupe cubes stored in different packaging over two temperatures (4 and 10°C). Error bars indicate standard deviations of the means. (A) 4°C and (B) 10°C.*