Quality of Minimally Processed and Packaged Fresh-cut Cantaloupe

KOUSHIK SAHA[1,*], S. PAUL SINGH[2] and BRUCE HARTE[2]

[1]*Research Associate, School of Packaging, Michigan State University, East Lansing, MI*

[2]*Professor, School of Packaging, Michigan State University, East Lansing, MI*

ABSTRACT: This study was undertaken to determine the quality of packaged fresh cut cantaloupe subjected to transport vibration after treating with various anti-browning agents. Cantaloupe (*Cucumis melo*) pieces were dipped in two anti-browning solutions: Treatment-A (2% ascorbic acid + 1% calcium chloride + 0.5% citric acid) and Treatment-B (3% NatureSeal™) for 2 minutes and packaged in bio-based clamshell containers and vibrated for 60 minutes (ASTM 4169, Truck assurance level II). Vibration of cut-cantaloupe packaged in sample containers had a positive effect on the flavor and overall liking. The overall liking scores were higher than 6(slightly like) on a hedonic scale of 1–9 for all samples except for vibrated-Treatment-A. The texture of vibrated cut-cantaloupe deteriorated with time, which was partially supported by firmness values obtained using a Kramer shear press. Treatment-B cut-cantaloupe subjected to vibration performed better than Treatment-A for appearance, flavor, texture and overall acceptability. No off-odor, sliminess or mold growth was observed in any of the samples during 10-day storage at 5°C ± 0.3°C. The sensory panel examined the final quality of fresh-cut fruit for several quality parameters at day 1, 4, 7 and 10 after being vibrated and stored in bio-based packaging made from Poly (lactide) (PLA) polymer. These findings are significant for quality preservation of cut-cantaloupe during transportation and distribution channels.

1.0 INTRODUCTION

FRESH cut fruits (FCF) are increasingly becoming popular in the marketplace. The FCF is a $300 million industry, projected to reach $1 billion by 2010 (IFPA, 2004). With growing health concerns, consumers are resorting to more nutritional options in their diet, such as FCF (IFPA, 2004). It is known that fresh cut fruits are more perishable than intact

*Author to whom correspondence should be addressed. Email: sahakous@msu.edu

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fruits (Watada et al., 1996) as a result of chemical and physical stresses during processing, handling and storage. At undesirable temperature, humidity, atmosphere and sanitary conditions can deteriorate product quality (Watada et al., 1996) mainly in appearance, flavor and purging at the bottom of the package. Respiration rates of FCF are normally higher than intact fruit and increases with temperature (Watada et al., 1996). Therefore it is recommended that FCF should be stored at lower temperatures unless there is a risk of chilling injuries. Another, important component which can affect FCF quality are transportation abuses. It is well known that whole fruits like mango, banana, tangerine and papaya get bruised and quality deteriorates more rapidly. Such spoilage is dependent on road conditions and type of trucks used to transport fruits (Chonhenchob and Singh, 2006). However consumers expect to buy cut fruits fresh and without any defects at a grocery store (Watada and Qi, 1999).Therefore, one of the on-going challenges is to delay browning and extend the shelf life of highly perishable FCF. This can be achieved by processing cut fruits with anti-browning solutions prior to packaging and distribution. Several studies have reported that ascorbic acid in combination with calcium chloride ($CaCl_2$) is an effective anti-browning agent (Chonhenchob and Singh, 2005). A commercially available anti-browning agent NatureSeal™ is a calcium ascorbate powder used extensively in the fresh cut industry. Ascorbic acid functions as reducing agent to deter surface browning (Whitaker, 1994) and $CaCl_2$ treatment provides tissue firming and has been reported to reduce browning (Drake and Spayd, 1983; Hopfinger et al., 1984). Also, non-biodegradable rigid containers made from PET (Polyethyleneterephthalate) and PS (Polystyrene) contribute substantially towards solid waste in a landfill. To combat this issue biodegradable rigid containers made from a PLA (Poly lactic acid) are increasingly becoming popular in the fresh cut fruit industry. Thus the objective of this study was to determine the effect of transport vibration and anti-browning agents on the sensorial attributes of fresh-cut cantaloupe packaged in bio-based plastic containers.

MATERIALS AND METHODS

Fresh Cut Processing

Whole cantaloupe was purchased from the local supermarket.The

whole cantaloupe was washed and dipped in a commercial sanitizer-Fruit & Vegetable Wash (SC Johnson Professional, Sturtevant, WI) (100-ppm chlorine) for 5 minutes. Following which they were stored in 5°C ± 0.3°C walk in chamber for a period of 12 hours prior to cutting. Once cantaloupes equilibrated to the desirable temperature, they were cut in 22°C ± 4°C environment. After removing seeds and peel, the cantaloupes were cut into 1-inch cubes using a sharp stainless steel knife cleaned in 100 pm chlorine solution (Figure 1) Cantaloupe pieces were dipped in two anti-browning solutions: Treatment-A (2% ascorbic acid + 1% calcium chloride + 0.5% citric acid) and Treatment-B (3% NatureSeal™ containing calcium ascorbate) for 2 minutes. Following which 180 ± 5 grams of cantaloupe pieces were packaged in bio-based clamshell containers (19.1 × 16.5 × 4.4 centimeters) made from poly (lactide) (PLA) (Figure 2). Twelve cantaloupe filled containers were packaged in corrugated fiberboard boxes (C-flute; FEFCO 0306 AB)(Dimensions- Lid: 51.4 × 41.3 × 5.7 cm ; Base: 48.9 × 40.6 × 15.6 cm) in 2 layers, 6 containers per layer, which were subjected to random vibration for 60 minutes to represent a 500 mile trip during distribution,

Figure 1. *Minimally processed fresh cut cantaloupe (size: 1 in^3) before transport vibration.*

Figure 2. *Cantaloupe filled containers packaged in corrugated box.*

(ASTM 4169, Truck assurance level II) on a vibration table (Lansmont Model 10000-10, Inc, Monterey, CA, USA) as shown in Figure 3. The cantaloupe filled containers were stored at 5°C ± 0.3°C for 12 hours before further evaluation and testing. These tested samples of PLA containers with fresh cut fruit were compared to "control" samples that had not been vibrated but were packaged and stored under identical conditions for the same period of time as the tested packages (Figure 4).

Sensory Evaluation

Each set of treated samples had a non-vibrated control container containing cut cantaloupe for comparison with vibrated and treated samples. Appearance, flavor, texture and overall liking of cut cantaloupe were evaluated by an eight-member panel on a hedonic scale of 1–9 hedonic (9 = Like extremely, 7 = like moderately, 5 = neither like nor dislike, 3 = dislike moderately, 1 = dislike extremely) for at day 1, 4, 7 and 10. A score of 6 was determined as the limit of marketability. Each panelist was provided with 4 samples (Table 1) in 2 oz cups labeled with random numbers. The test setup is shown in Figures 5 and 6.

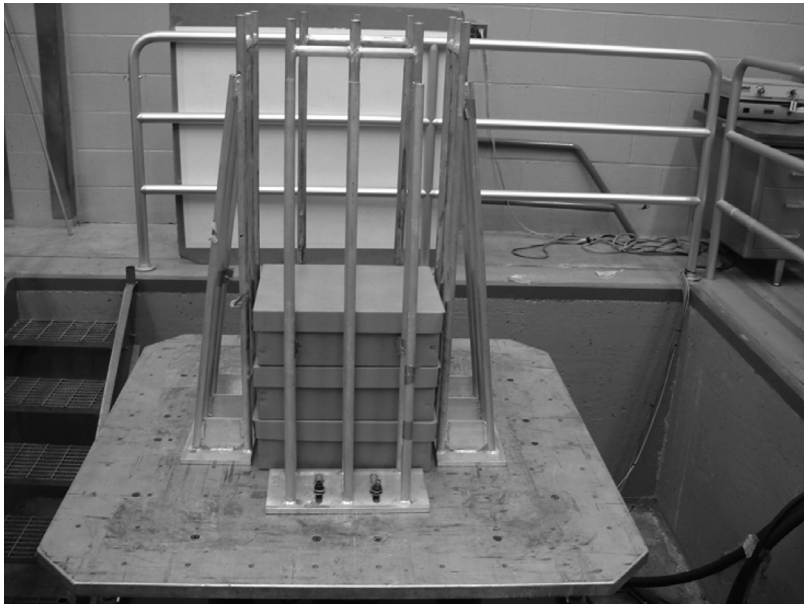

Figure 3. *Cantaloupe filled containers packaged in corrugated boxes subjected to random vibration.*

Figure 4. *Comparison of control versus minimally processed fresh cut cantaloupe after transport vibration.*

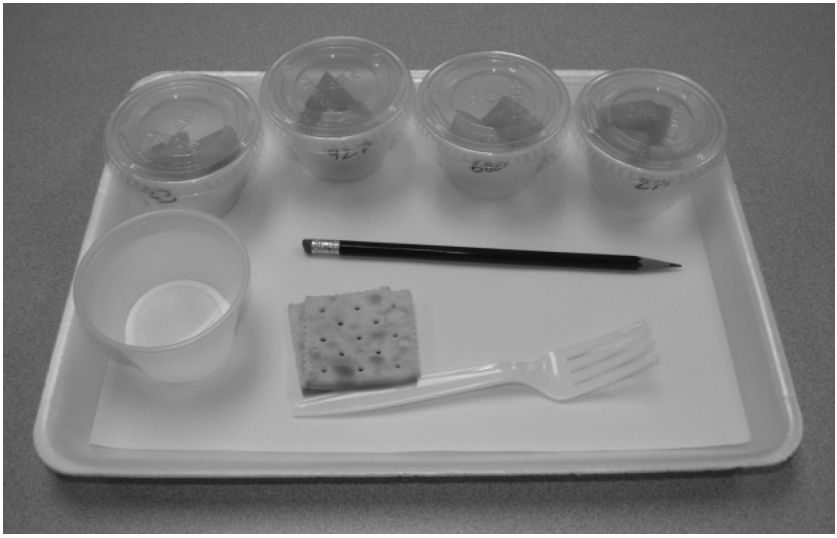

Figure 5. *Tray setup presented to sensory panelist.*

Figure 6. *Sensory panelist booth for testing fresh cut cantaloupe.*

Table 1. *Sensory Evaluation Samples Provided to Panelists.*

Samples	Description
Control A	Non-vibrated and Treatment A
Tested A	Vibrated and Treatment A
Control B	Non-vibrated and Treatment B
Tested B	Vibrated and Treatment B

Instrumental Texture Analysis

A Kramer shear press (Model FTA-300, FTC, Stering, VA) was used to determine flesh firmness at 1, 4, 7 and 10 days to compare it with texture scores from sensory evaluation. A sample holder ($6.6 \times 6.6 \times 6.4$ cm) was loaded with 60 grams of cut cantaloupe cubes. Upon placing the sample holder in the test cell 10 movable blades were lowered at 20 cm/min, compressing the cut samples to a distance of 10.2 cm. Following which the force required to compress test sample was recorded.

Statistical Analysis

The collected data was analyzed using statistical software Minitab 13.1 (Minitab Inc, State College, PA, USA). Analysis of variance was performed on sensory and firmness data and the means were separated using Fisher's LSD at significance level of $p \leq 0.05$.

RESULTS AND DISCUSSION

Sensory Evaluation

a) Appearance

Fresh cut cantaloupes stored in PLA containers and subjected to their respective treatments were evaluated for the attributes mentioned in the methods section. The appearance of cantaloupe showed a general trend of deterioration with time (Figure 7). One day after processing and vibration there was no significant difference in appearance (Figure 7) between cut cantaloupe processed with Treatment A and Treatment B. However, cut cantaloupe 'Control B' (6.63a) appeared to be better than 'Control A' (6.25a), 'Tested A' (6.25a) and 'Tested B' (6.25a) (Figure 7) at day 1. Even though 'appearance' deteriorated with time (Figure 7) it

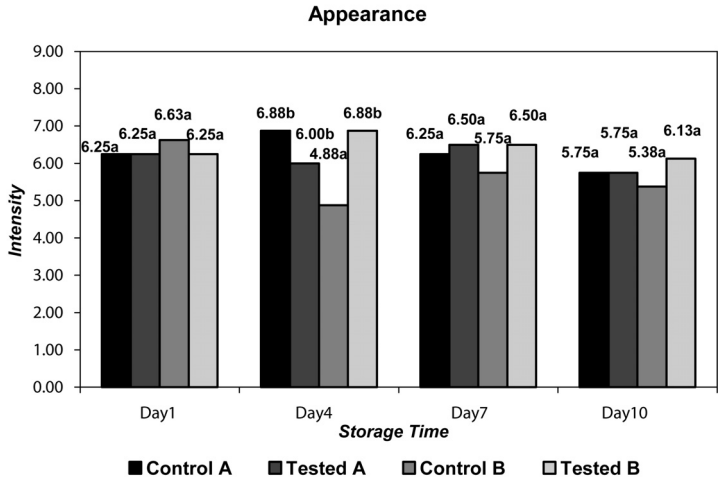

Figure 7. *Sensory scores for fresh cut cantaloupe appearance over storage period. 1 = Dislike extremely; 9 = Like extremely. *Mean scores with different letters are significantly different.*

was observed that the appearance scores for 'Tested B'(6.13a) samples were higher than 'Control A'(5.75a), 'Tested A'(5.75a) and 'Control B'(5.38a) by day 10. This indicates that fresh cut cantaloupe treated with Natureseal™ and subjected to vibration had the best appearance over a period of 10 days.

b) Flavor

It was observed that the day 1 flavor scores compared to Day 4 had lower hedonic scores for all the treatments except for 'Tested B' (7.0a) at day 1. Also, at day 1, 4 and 7 'Tested B' cantaloupe samples were rated to have better flavor scores than its 'Control B' samples (Figure 8). Similarly at day 1 and 7 'Tested B' samples had higher flavor scores than 'Control A' (Figure 8). This is possibly due to ripening of cut cantaloupe as a result of higher respiration rate and ethylene induced ripening during storage. Ethylene production as a consequence of cutting has been observed in tomato (Lee et al., 1970), strawberry (Abeles et al., 1992) and papaya (Paull and Chen, 1997) leading to accelerated ripening. Similarly, cantaloupe has shown high ethylene release upon cutting (Hoffmann and Yang, 1982). Also, several cut fruits have shown higher respiration rates than whole fruits (Watada et al, 1990; Cantwell, 1992) leading to shorter shelf life. Therefore accelerated ripening due to increased ethylene production and respiration rate can explain better 'fla-

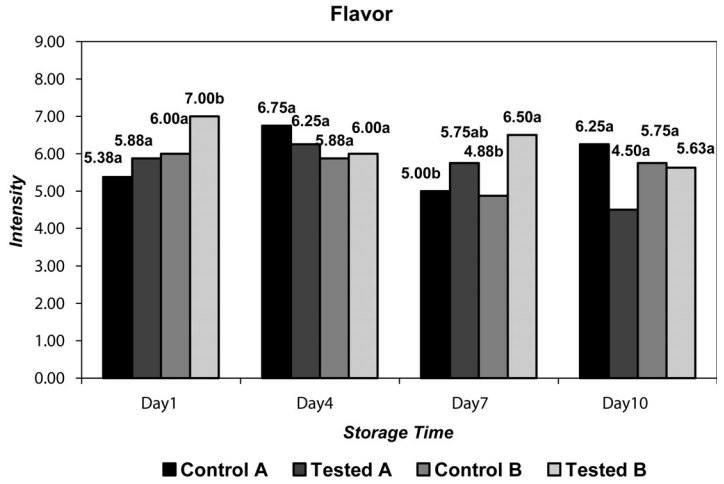

Figure 8. *Sensory scores for fresh cut cantaloupe flavor over storage period. 1 = Dislike extremely; 9 = Like extremely. *Mean scores with different letters are significantly different.*

vor' scores at day 1, 4 and 7 for the samples which were exposed to mechanical vibration. This indicates that vibration during distribution has some positive effects in enhancing flavor of fresh cut cantaloupes. However at the end of the study 'Control A' samples had the highest flavor scores (Figure 8).

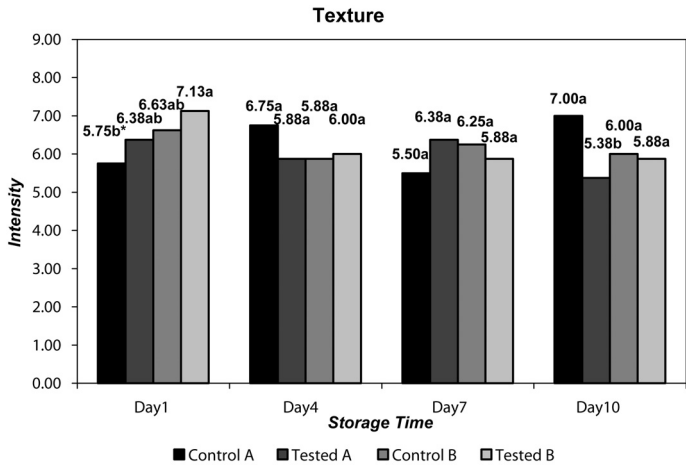

Figure 9. *Sensory scores for fresh cut cantaloupe texture over storage period. 1 = Dislike extremely; 9 = Like extremely. *Mean scores with different letters are significantly different.*

c) Texture

Overall the texture of all the sample treatments deteriorated with time except for 'Control A' samples (Figure 9). 'Control A' samples were rated with the highest texture scores (6.75) at day 4 and day 10 (7.0) compared to day 1 samples (5.75) (Figure 9). Initially 'Tested B' had the best texture scores but it deteriorated with time from a score of 7.13 at day 1 to 5.88 at day 10. Where as, 'Control A' sample had the best texture (7.0) at day 10 compared to the remaining treatments. The texture of 'Tested A' and 'Control B' was observed to be similar at day 1, 4 and 7 (Figure 9). Therefore, it can be concluded that at the end of the study the 'Control A' samples (7.0a) were observed to have the best texture followed by 'Control B'(6.0a), 'Tested B'(5.88a) and 'Tested A'(5.38b) samples by day 10.

d) Overall Liking

Initially it was observed that 'Tested B' samples had the highest overall liking score of 7.0 at day 1 followed by 'Control B' (6.5ab), 'Tested A' (5.75ab) and 'Control A' (5.63b) (Figure 10). At day 4 'Control A' samples were rated to have the highest overall score of 7.13. 'Tested A' samples were preferred over 'Control A' samples at day 7. Similarly, 'Tested B' samples had higher overall scores than 'Control A' at day 1, 4, 7 and 10 (Figure 10). This indicates that there can be a positive effect

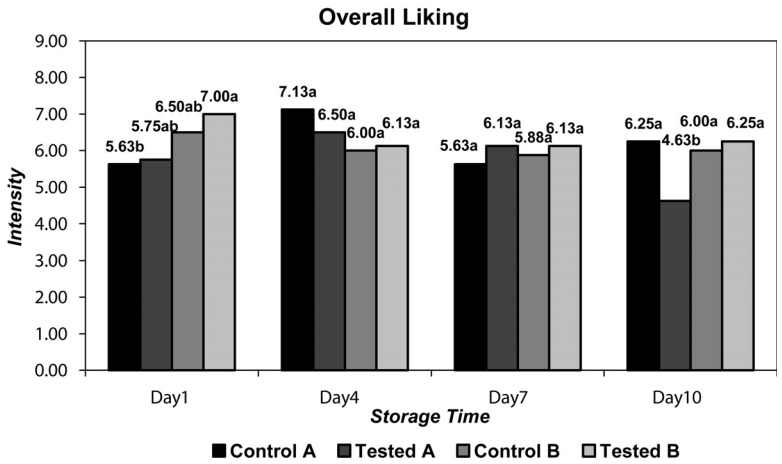

Figure 10. *Sensory scores for fresh cut cantaloupe overall liking over storage period. 1= Dislike extremely; 9= Like extremely. *Mean scores with different letters are significantly different.*

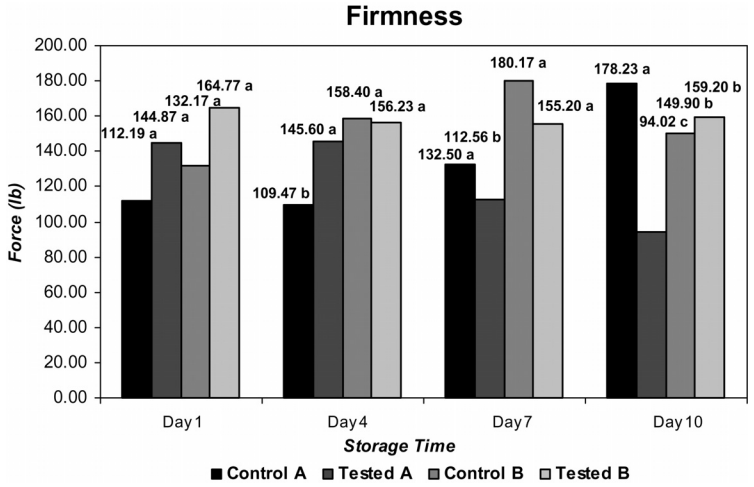

Figure 11. *Kramer firmness of fresh cut cantaloupe over storage period. *Mean scores with different letters are significantly different.*

of vibration during distribution on the overall acceptability of a sample at a particular storage time.

Firmness Measurements

There was no direct correlation between firmness measurement and texture scores from the sensory panelists. However by day 10 the firmness values for 'Control A' sample (178.23 lb) was observed to be the highest followed by 'Tested B' (159.20b), 'Control B' (149.20b), and 'Tested A' (94.02c).Comparing this trend to texture scores as observed at day 10 by the panelists (Figure 9), it can be seen that cut fruit firmness is related to its texture during storage. Also, the firmness of the cut cantaloupe was observed to be somewhat decreasing from day 1 to day 10 for 'Tested A' and 'Tested B' samples (Figure 11), showing that there is a distinct effect of vibrational forces on firmness during transportation. Thus, softening of cantaloupe flesh can be expected as these samples are subjected to vibrational forces during the transportation. It was interesting to find that vibration tested cut cantaloupe with 'Treatment B' (159.20 lb) had higher firmness values than 'Treatment A' (94.02 lb) at day 10. This is indicative that commercially available anti-browning solution Natureseal™ will perform better in preserving cut fruit texture in a transport environment.

CONCLUSION

Vibration of fresh cut-cantaloupe packaged in sample containers had a positive effect on the flavor and overall acceptability. The overall liking scores were higher than a hedonic score of 6 (like slightly) for all samples except for vibrated-Treatment-A. The texture of vibrated cut-cantaloupe deteriorated with time. There was some evidence of correlation between by firmness values and texture scores at day 10 (Figures 9 and 10), which shows that flesh firmness and texture scores at the end of the storage period is better in control samples compared to vibration tested samples. Thus, it can be said that vibrational forces during transportation as an effect on texture quality of cut cantaloupe. Treatment-B cut-cantaloupe subjected to vibration performed better than Treatment-A for appearance, flavor, texture and overall acceptability. No sliminess or mold growth was observed in any of the samples during 10-day storage. Finally, these findings are significant for quality preservation of cut-cantaloupe during transportation and distribution channels.

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