

Changes of postharvest quality in ‘Bagdadagi’ cucumber (*Cucumis sativus* L.) by storage temperature

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Abstract: ‘Bagdadagi’ cucumber (*Cucumis sativus* L.) fruits with half light green skin and tiny white spines grown at greenhouse of the Cheonan-city in the middle part of Korea were harvested in October in 2013, and then stored at 0, 5, 10, 13 °C, and room temperature for 25 days. Quality and sensory parameters such as CO₂ production, weight loss, soluble solids contents, firmness, skin color, yellowing index, overall quality were evaluated during storage. The fruits stored under low temperatures showed the reduced weight loss as well as CO₂ production compared with fruits stored in room temperature. But, The fruits stored at 0, 5 °C showed high increase of CO₂ production after 2 days transfer to room temperature. Soluble solids contents, firmness showed the smallest changes in fruits at all treatments during storage. Chilling injury symptom of watery surface pitting was found in fruits stored at 0 and 5 °C and decay after transfer to room temperature. Yellowing was severe in fruits stored at 13 °C and room temperature. From the results, storage of at 10°C was selected as an optimal temperature of ‘Bagdadagi’ cucumber for maintaining storage life up to 20 days.

Keywords: Postharvest, ‘Bagdadagi’ cucumber, quality and storage temperature

1. Introduction

Cucumber is a very popular vegetable due to high water content and unique flavor. Cucumber cultivar in Republic of Korea varies by growing region. In recent years, The consumer’s preference about Bagdadagi cucumbers have been expanding gradually due to good taste and long storage life after making kimchi and dominated than other cucumber type (Lee et al., 2014). Bagdadagi cucumber fruits are middle-size with half light green near white skin and tiny white spines (Jung, 2013). They are thought to have cultivar improvement done with cultivated in Republic of Korea since old times. It is possible to obtain year-round harvests in protected cultivation systems. Cucumber reaches commercial maturity at a physiologically immature stage (Kays, 1999). After harvest, the quality of a commodity starts to decline, temperature management is generally the most effective and the most used tool to extend the postharvest life of many horticultural commodities, including cucumbers (Kader,

2002). Cucumbers suffer chilling injury above freezing temperatures and generally should not be stored long term below 7 to 10°C (DeEll et al., 2000); optimum storage temperature for cucumbers is 10 to 12.5°C at ~95% relative humidity (Kader, 2002). Research related to the postharvest technology of Bagdadagi cucumbers in Korea is limited. Therefore, the objective of this experiment was to determine the optimum storage temperature for Bagdadagi cucumber.

2. Materials and Methods

2.1. Plant Material

Bagdadagi cucumbers (*Cucumis sativus* L. cv. Joemun Baegdagi) were grown under commercial greenhouse conditions at Cheonan-city in the middle part of Republic of Korea. Cucumbers were harvested on Oct., 10, 2013 and packed in 40 cucumbers in unwaxed corrugated cartons and were stored for 20 days at 0, 5, 10, 13°C, and room temperature (RT; 20.1~27.1°C, average 22.6°C). Bagdadagi

cucumbers used in this test had an average weight of 205.5 g, an average length of 239 mm and an average equatorial diameter of 34.2 mm.

2.2. Respiration and Ethylene Production

Two cucumber fruits in triplicate placed in 2 L plastic containers equipped with septa and sealed for 2 h at different storage temperatures every 5 days for 20 days and after being transferred from its original storage temperature to RT for 2 days. Both ethylene and CO₂ production measurements were conducted using 1 mL headspace samples withdrawn with a syringe and analyzed using GC (HP6890, Hewlett Packard, USA). For ethylene determination, 1 mL of headspace gas was analyzed using a FID detector equipped with an activated alumina column. Injector, oven, and detector were operated at 110, 70, and 250°C, respectively. For CO₂ determination, 1 mL of headspace gas was analyzed using a thermal conductivity detector (TCD) detector.

2.3. Weight Loss

Weight loss was determined by tracking 2 cartons (40 cucumbers per carton) every 5 days for 20 days and expressed as a percent of the original weight.

2.4. Total Soluble Solids Content

Juice samples used for total soluble solids (TSS) content measurements were obtained by squeezing half of the apple slices from each replicate with a hand juicer. Samples were then filtered through three layers of cotton gauze. TSS of the juice was measured at room temperature with a digital refractometer (Model PAL-1, Atago Co., Japan).

2.5. Firmness

Fruit firmness was assessed using an Texture Analyzer (TA XT2, UK) equipped with a 3.0 mm diameter probe with a crosshead speed of 2.5 mm sec⁻¹ and a 12 mm displacement. Firmness was evaluated at the mesocarp area (between the epidermis and locular tissue) of similarly sized, equatorial 20 mm slice of fruit. Firmness measurements were taken per slice (n = 5) and averaged to obtain a final value.

2.6. Color Evaluation

External color was assessed using a Minolta Chroma Meter (model CR-400, Minolta Co., Japan). The color values of a* and b* were converted into hue angle [hue = tan⁻¹(b*/a*)]. Measurements were taken on equatorial opposite sides of the fruit (n = 5) and averaged to obtain final value.

2.7. Visual Quality Assessment

Fruit were visually assessed for yellowing, pitting, pathogen infection or any other disorder that could render the commodity unmarketable and expressed as a percent of the total fruits at 14 days of storage. Overall visual quality was evaluated by using 9-point hedonic scale (9 = excellent, 7 = good, 5 = fair, limit of marketability, 3 = poor, 1 = very poor).

Overall visual quality assessments were made every 5 days for 20 days.

2.8. Microscopic Observation

Fruit were microscopic observed sound cucumber stored at 10°C and chilling injured cucumber stored at 0°C for 14 days in storage. Cross sections of specimens were observed under light microscope, and the process and method for observation were as follows: Samples (about 2 mm) were fixed with 2.5% glutaraldehyde in 0.1 M sodium phosphate buffer (pH 7.2) for 2 h at 4°C. Specimens were then rinsed, post-fixed with 1% osmium tetroxide (in the above buffer) for 2 hrs, at 4°C, and held overnight in phosphate buffer. After fixation, specimens were dehydrated in a graded series of ethyl alcohol (40, 60, 80, 90, 95 and 100% in distilled water [v/v]), to ensure complete dehydration, processed tissue through 3 changes of propylene oxide, for 15, 15, 30 min. per changes, and gradually infiltrated (3 h each at 30, 50, and 100% embedding media in propylene oxide) with embedding media, Epon. Specimens were held overnight in 100% Epon before polymerization at 60°C for 72 h. Specimens were sectioned (2000 nm), stained with periodic acid staining (P.A.S), and viewed with Axioskop 2 light microscope (Carl Zeiss, Germany).

3. Results

3.1. Respiration and Ethylene Production

The storage temperature significantly affected the respiration of Bagdadagi cucumber fruit in storage (Fig. 1).

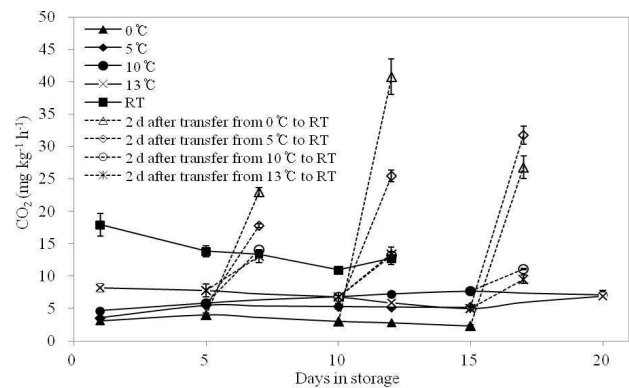


Fig 1. Respiration of Bagdadagi cucumbers at different storage times and temperatures and 2 d after transfer to RT. Vertical bars represent standard error of three replicates.

Respiration rate of fruit stored at RT higher than fruit stored at low temperature storage, the lowest temperature (0°C) effectively suppressed the respiration rate than 5, 10, 13°C. When removed from each storage temperature at 5, 10, 15 days and 2 days after transfer to room temperature, respiration of fruit stored at 10, 13°C were similar level to fruit stored at RT but respiration of fruits stored at 0, 5°C were sharply increased. Ethylene levels of Bagdadagi cucumber fruit in storage occurred in trace amounts, fruit

stored at 0, 5°C were sharply increased (Fig. 2).

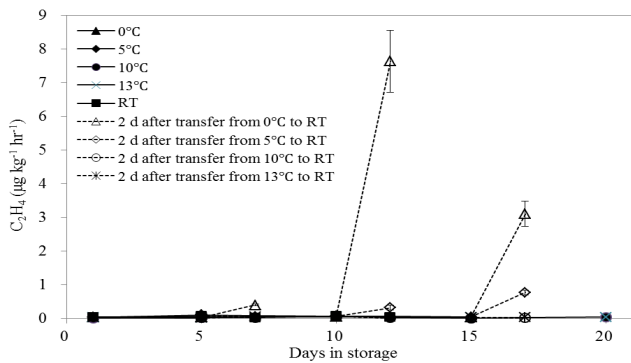


Fig 2. Ethylene production of Bagdadagi cucumbers at different storage times and temperatures and 2 d after transfer to RT. Vertical bars represent standard error of three replicates.

When removed from each storage temperature at 5, 10, 15 days and 2 days after transfer to room temperature, ethylene production of fruit stored at 0, 5°C were sharply increased.

3.2. Weight Loss

Evaluations of postharvest quality of Bagdadagi cucumbers were carried out after the fruit had been in storage for 5, 10, 15 or 20 days. Weight loss was significantly highest in fruit stored at highest temperature (RT) during the storage period (Fig. 3).

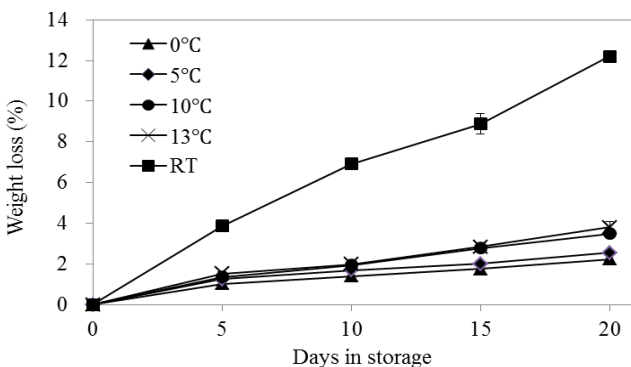


Fig 3. Weight loss of Bagdadagi cucumbers at different storage times and temperatures. Vertical bars represent standard error of two replicates.

At 20 days of storage, The highest weight loss, 12%, was observed in storage at RT; the least weight loss observed in cucumbers stored at 0°C, which lost 2.2% of the initial weight. There were no significant differences in weight loss at 10 or 13°C, which was 3.5% or 3.8%, respectively.

3.3. Total Soluble Solids Content

Total soluble solids (TSS) content, although variable during the storage period, tended to remain between 3.5 to 2.9 °Bx (Fig. 4).

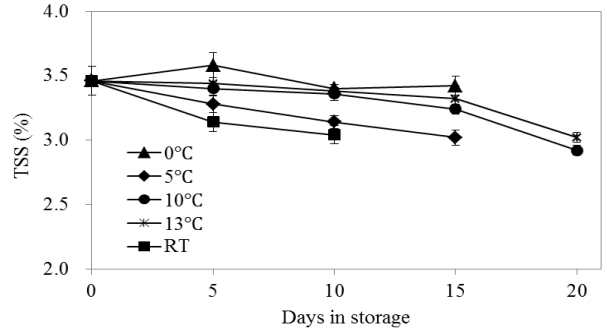


Fig 4. Total soluble solids content of Bagdadagi cucumbers at different storage times and temperatures. Vertical bars represent standard error of five replicates.

Initial TSS was 3.5 °Bx, fruit stored at RT or 5°C declined significantly during the storage period.

3.4. Firmness

The storage temperatures had no significant effect on the flesh firmness of stored cucumber. Firmness remained between 8.4-9.7 N (data not shown).

3.5. Color Evaluation

The hue angle of fruit stored at RT decreased after 5 days in storage, and fruit stored at 5 °C decreased after 10 days (Fig. 5).

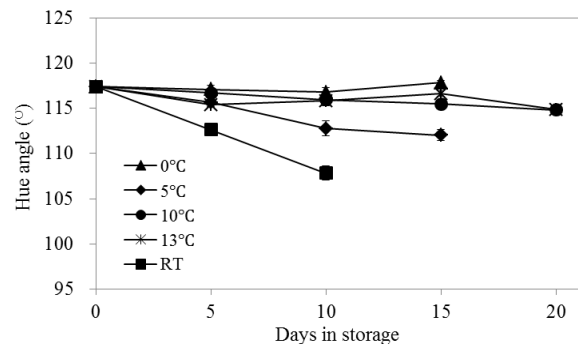


Fig 5. External color (hue angle) of Bagdadagi cucumbers at different storage times and temperatures. Vertical bars represent standard error of five replicates.

Table 1. Percentage of fruit was shown the listed visual symptoms at 14 days in storage.

Temperature	Decay	Yellow spot	watery surface pitting	Sound
0°C	0	0	73	28
5°C	8	0	38	55
10°C	5	0	0	95
13°C	0	100	0	0
RT	0	100	0	0

Lower hue angle values indicate a departure from green towards yellow in the L*a*b* color chart. Fruit stored at 5, 10 and 13°C had no variability in external color.

3.6. Visual Quality Assessment

At 14 days of storage, the surface of cucumber fruit stored at 0 and 5°C had prevalent watery surface pitting, indicative of chilling injury (Table 1).

In contrast, fruit stored at 10, 13°C or RT had no watery surface pitting. Fruit stored at 5°C was pale green externally. The appearance of fruit stored at 13°C or RT showed small yellow spots (yellowing) and became unmarketable while fruit stored at 10°C retained good appearance after 20 days storage (Fig. 6).

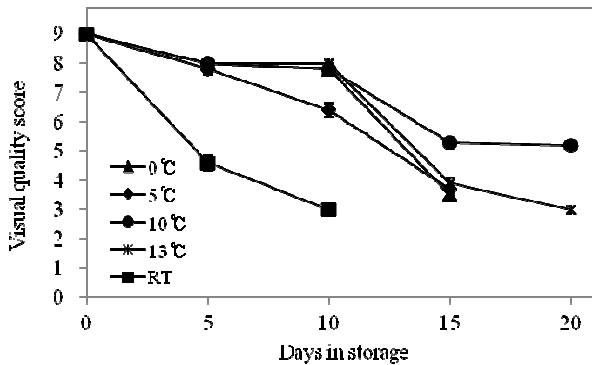


Fig 6. Visual quality of Bagdadagi cucumbers at different storage times and temperatures. Vertical bars represent standard error of five replicates.

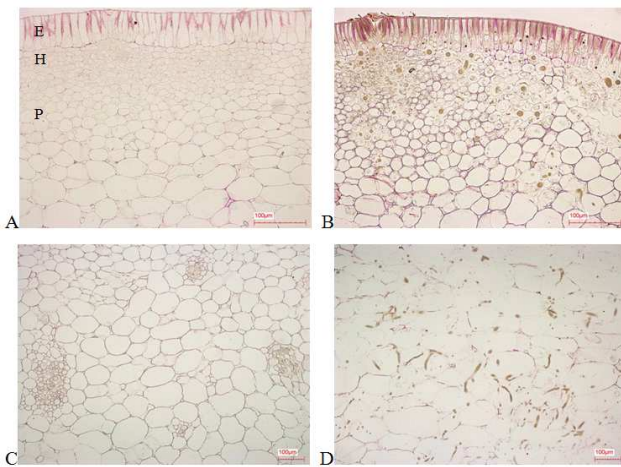


Fig 7. Light microscopic images of transversal sections of sound cucumber stored at 10°C and chilling injured cucumber stored at 0°C for 14 days in storage. A: transversal section image ($\times 100$) of sound cucumber including epidermis (E), hypodermis (H) and parenchyma (P) tissue, B: transversal section image ($\times 100$) of chilling injured cucumber, C: transversal section image ($\times 200$) of parenchyma tissue of sound cucumber, D: transversal section image ($\times 200$) of parenchyma tissue of chilling injured cucumber.

3.7. Microscopic Observation

The microscopic characteristics of sound cucumber, hypodermal cells just beneath the epidermal cells were flattened, while cells of parenchyma tissue were bigger and round (Fig. 7).

Chilling injured cucumber symptoms which had watery surface pitting and decay symptom, fungal invasion were detected through hypodermis and parenchyma tissue, cell wall of parenchymatous cells in the internal flesh tissue was

damaged and a portion of cells collapsed.

4. Discussions

In these experiments the maximum marketable life was obtained when Bagdadagi cucumber fruit was stored at 10°C. Storage of cucumbers at 0 or 5°C reduced the quality due to chilling injury while quality at 13°C or RT was reduced due to the development of yellowing (small yellow spots) that negatively affected appearance. Some scholars indicated that chilling injury in cucumbers can vary depending on the cultivar (Hakim *et al.*, 1999; Thompson, 2002). It is generally accepted that cucumber storage below 10°C will cause chilling injury thus limiting the shelf life of the product, and is commonly followed by *Alternaria* rot (Saltveit, 2004). Pitting in cucumber fruit has been associated with combination of factors, as epidermal cracks, the collapse of parenchyma tissue (Tatsumi *et al.*, 1987). Microscopic characteristics of chilling injured Bagdadagi cucumber were observed destruction of parenchymatous cells. Abe (1990) has classified that type I pitting (affecting parenchymatous cells), or type II (affecting both epidermal and hypodermal cells). In Bagdadagi cucumber fruit, type I pitting was observed.

5. Conclusion

Storage of at 10°C was selected as an optimal temperature of Bagdadagi cucumber for maintaining storage life up to 20 days.

Acknowledgements

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