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Effect of Packaging Conditions on Physiology Quality and Shelf-life of Fresh-cut Kiwifruit

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Abstract. Impacts of packaging conditions on shelf-life quality of fresh-cut 'Lushanxiang' kiwifruit were investigated during 12 d of storage at 4 ◦C. Fruit slices were wrapped in 64 μm polypropylene (PP) film flushing with high CO_2 (40% or 10%) atmosphere or passive modified atmospheres (air). Measurements of firmness, total phenolic content, chlorophyll and microbial growth were evaluated over time. Active packaging with the initial 10% CO_2 plus 5% O_2 was the most effective in maintaining flesh firmness, total phenolic and chlorophyll content, which was still 11N, 0.75 mg/mL and 0.09 mg/g respectively. Both 40% and 10% CO_2 active modified packaging significantly inhibited the microbial grows. Further researches are needed to evaluate the sensory aspects, as well as to characterize the flesh translucency phenomenon of fresh-cut kiwifruits.

Introduction

Modified atmosphere packaging (MAP) and refrigeration are the main methods used to reduce undesirable quality changes and extend the shelf-life of fresh-cut products. Packaging conditions as well as cultivar could affect the color, texture, appearance and microbial growth during the shelf-life of fresh-cut fruits. CO_2-enriched atmospheres have been applied extensively to prolong the shelf-life of fruits by inhibiting flesh softening and decay [1]. However, CO_2-enriched atmospheres with low O_2 can also adversely affect ascorbic acid, the fruit color and nutritional value [2] depending on the commodities cultivars. The optimal storage conditions and initial gas concentration rely on the metabolic characteristics of the specific product [3].

Kiwifruit is commercially necessary as fresh-cut fruit and has been researched regarding its preservation as sliced fruit, through the application of volatile compounds, treatment with hydrogen peroxide, calcium lactate, and MAP. However, slicing processing cause a rapid increase in CO_2 and ethylene production accompanied with the wounding response which decrease the quality of fresh-cut products [4].

The objective of the research was to evaluate the effect of different initial atmosphere packaging conditions on the quality attributes and shelf-life of 'Lushanxiang' fresh-cut kiwifruits..

Materials and methods

Materials. Kiwifruit were selected for uniformity of size and absence of defects to be used in the experiment. The fruits were washed and sanitized with 200 μLL^{-1} sodium hypochlorite to have a maximum sanitizing effect prior to processing. Fruit were peeled and cut into 2 cm-thick slices and then the fruit slices were dipped into 1% citric acid and 1% ascorbic acid solution for 2min as antibrowning agents; excess water was drained for 2min.

Packaging Conditions and Storage. Portions of 100 g of fresh-cut kiwifruits were placed into PP trays (500 cm^3, MCP Performance Plastic Ltd., KibbutzHamaapil, Israel). These were wrapped with a 64μm of thickness PP film with a permeability to O_2 and CO_2 of 110 and 550 $cm^3\ m^{-2}\ bar^{-1}\ d^{-1}$ at 23 ◦C and 0% RH, respectively (Tecnopack SRL, Mortara, Italy) using a MAP machine (Ilpra Foodpack Basic V/G, Ilpra, Vigenovo, Italy).

Three packaging conditions were established: (T1) PP-40%CO_2: fresh-cut kiwifruit in PP trays flushing with high CO_2 level (40% CO_2 plus 5% O_2); (T2) PP-10% CO_2: fruits in PP trays filled with 10% CO_2 plus 5% CO_2); (T3) PP-air: fresh-cut kiwifruit in PP trays filled with air (20.9% O_2); (CK) fresh-cut kiwifruit stored in air without packaging served as the control.

Firmness and SSC. Flesh firmness was measured by puncture with a Chatillon Force TCD 200 and Digital Force GaugeDFIS 50, (Jonh Chatillon & Sons, Inc.U.S.A.), fitted with a flat 8 mm diameter tip, on kiwifruit slices, to a depth of 7 mm. The SSC (°Brix) was determined by a digital refractometer, model PR1-Atago Co. LTD, Japan, in kiwifruit juice.

Total phenolic Content and Chlorophyll. Content of total phenolics were measured by the Folin-Ciocalteau reagent method [5]. Chlorophyll content was recorded using N, N-dimethylformamide [6].

Microbiological Analysis. Changes in population of fresh-cut kiwifruit were studied by yeast and mould counts according to the ISO 7954:1987 guideline using Chloramphenicol Glucose Agar (CGA) (Biokar Diagnostics, Beauvais, France) and the spread plate method. Analyses were performed in randomly sampled pairs of trays, with two replicate counts per tray.

Statistical Analysis. ANOVA of data was performed for this experiment. Differences between means of data were compared by least significant difference (LSD) using Duncan's multiple range test. Differences at $P \leq 0.05$ were considered significant.

Results and Discussion

Firmness and SSC. Firmness showed great changes during storage and significant differences were observed over time and among packaging conditions (Fig 1). PP-10% CO_2 packaging reduced the loss of the fruit firmness and kept the firmness over 8N at the end of the storage, and the figure was 39.7% higher than fruit in control. Without the initial high CO_2 treatment, a continuous decrease of firmness occurred during storage. The results proved that PP-10% packaging retarded tissue softening. There was a rapid increase of SSC within the early 4 days except the T2 (Table. 1). Thereafter, gentle increase occurred until day 8 followed by a slight increase. Cut fruit with initial CO_2 packaging pre-treatment had lower levels of soluble solids than those without high CO_2 treatment. Soluble solids concentration in fruit treated with high CO_2 packaging remained low during storage.

Phenolic concentration. Initially, the phenolic concentration was approximately 1.5 mg mL^{-1} fruit. The control showed a remarkable decrease in total phenolic (46%) after 3 days of storage, while T2 treatment produced the lowest decrease (10%). Furthermore, high positive correlations were found between total phenolic and vitamin C for all treatments (data not shown). However, the high phenolic concentrations promoted browning after 12 d, which makes fresh-cut kiwifruit not

suitable for marketable after this time. But it is long enough for food services and fast food. Therefore, the treatment of intact kiwifruit with high CO_2 could be an alternative to the technologies currently in use for prolonging the shelf-life of the 'Lushanxiang' pear variety as a fresh-cut product.

Chlorophyll. Fig3 suggests that chlorophyll was significantly maintained by T2 treatment. Values of chlorophyll in high CO_2-treated samples were higher than in control samples, especially after 6 d. At the end of the storage time, the chlorophyll level was 3.8 mg $100g^{-1}$ which was more than 3 times than the control. But the chlorophyll content in PP-40% CO_2 showed a significant decrease during the whole storage time.

Microbial Stability. Fig. 4 shows the development of mould and yeast on fresh-cut kiwifruit during cold storage. No significant differences ($p < 0.05$) were found among PP-40% CO_2 (T1) packaging and PP-10% CO_2 conditions (T2) for the microbial growth at the first 6 days; but significant differences were found over shelf-life period. Initial populations ranged from3 to 4 log $CFUg^{-1}$ for mould and yeast at day 0 and reached 8-9 log $CFUg^{-1}$ after 12 d. Similar increase was observed for mesophilic and psychrophilic bacteria at 4 ◦C (data not shown). The results suggested that both of the high CO_2 packaging were effective at inhibiting the mound and yeast growth. Mound and yeast counts were applied to define the shelf-life of fresh-cut kiwifruit, because the microorganisms were subject to exceed regulation limits. Packaging in high CO_2 modified atmosphere extended the shelf-life of 'Lushanxiang' fresh-cut kiwifruit by 12 d of storage.

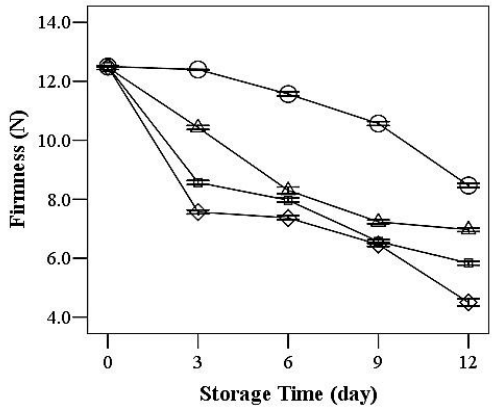

Fig.1 Effect of packaging on firmness of fresh-cut kiwifruits ○-T2, △-T1, □

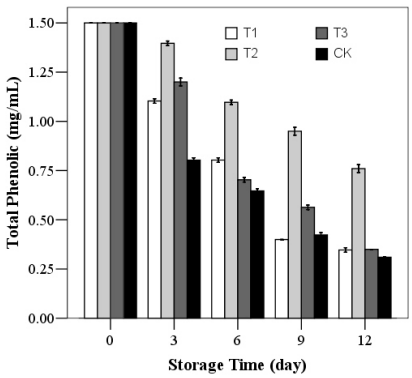

Fig.2 Effect of packaging on total phenolic of fresh-cut kiwifruits during storage

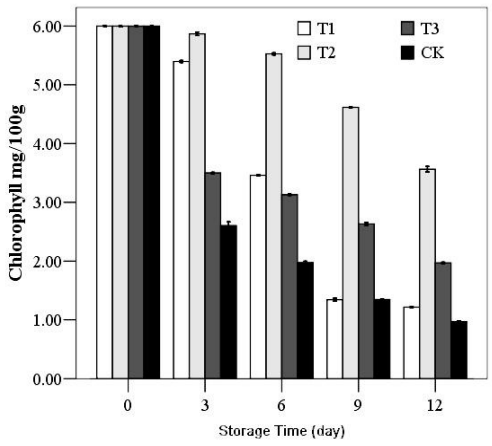

Fig.3 Effect of packaging on chlorophyll content of fresh-cut kiwifruits

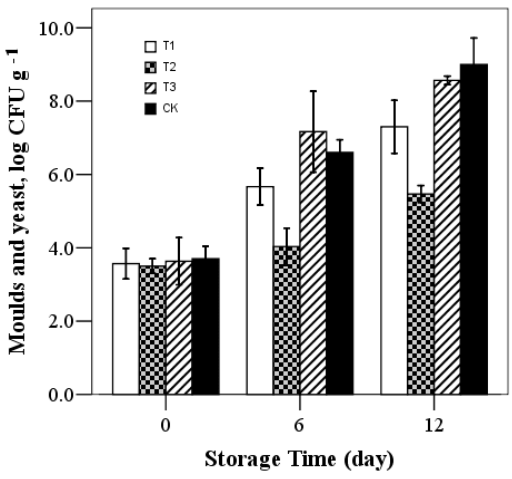

Fig.4 Effect of packaging on mounds and yeasts of fresh-cut kiwifruits

Table1. Effect of packaging conditions on the SSC content of fresh-cut kiwifruit. Each value represents the mean of 3 replicates. Means followed by the same letters are not significantly different for P =0.05.

day	T1	T2	T3	T4
0	12.0a	12.0a	12.0a	12.0a
4	14.5b	12.1a	13.9a	14.8b
8	14.0b	12.4a	15.7c	15.9c
12	14.5b	12.6a	16.4d	14.3b

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Conclusions

In conclusion, the advantages of elevated CO_2 in maintaining shelf life and postharvest quality of kiwifruit have been reported, but adverse effects of initial 40% CO_2 on chlorophyll stability, particularly in the interior of the fruit was noted. Several suggestions to explain these changes were discussed, but further research on the effect of CO_2 packaging on both microbiological safety and stability of chlorophyll is necessary. Moreover, the tolerance of 'Lushanxiang' kiwifruit to high CO_2 levels depended on both temperature and CO_2 concentration in packaging.

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