EFFECT OF PERFORATION MODIFIED ATMOSPHERE PACKAGING ON QUALITY OF FRESH-CUT CARROT DURING STORAGE

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The aim of this work was to evaluate the effect of perforation modified atmosphere packaging on quality of carrot slices during 12 days of storage at 5 °C. Polyethylene bags with different number of perforations (3, 4 and 6) were used in this experiment. Headspace oxygen concentration, respiration, weight loss, surface color, firmness, pH, and soluble solid content were examined throughout storage. It was observed, that all the investigated packages were equally effective in maintaining the quality of carrot slices. There was no symptom of decay till the end of the experiment. In addition, pH, soluble solid content and firmness showed only minor change. Moreover, weight loss of carrot slices was below 2 % after 12 days of storage. Thus, perforation modified atmosphere packaging (MAP) has been proved to be efficient in maintaining the quality of slice carrot.

Keywords: carrot, fresh-cut, MAP, storage

Introduction

Nowadays, food quality is an interesting topic comprising a set of standards about nutrition, safety and sensory characteristics of produce (Nyarko et al., 2016, Ukuku, 2006). These factors influence the customer acceptance (Mc Kay et al., 2011). In order to meet the market requirement, alternative technologies have been applied in food processing including modified atmosphere packaging (MAP), high hydrostatic pressure (HHP), ohmic heating, pulsed electric fields, micro-wave heating and ultra sound (Deliza et al., 2005). MAP is one of the powerful techniques that is widely used for extending the shelf-life of fresh-cut product.

Fresh-cut is currently a growing market because of its convenience, and availability (Alandes et al., 2009). Carrot being an important vegetable is popularly used in ready-to-eat salads due to rich source of vitamin A and potassium. The aim of this study was to investigate the effect of MAP with different number of perforations (3, 4, and 6) on quality of carrot slices during storage at 5 °C.

Materials and methods

Materials

Carrots (*Daucus carota L.*) were purchased from the wholesale market, Budapest, Hungary.

The laser perforation of polyethylene (PE) films (50 µm thickness) was used for preparation of packages (20 x 30 cm^2). The perforated holes were in the range of 75 – 100 µm.

Carrot processing and packaging procedures

Carrots were selected the same size with diameter of 3 cm, peeled and cut into slices of 0.5 cm thickness. After that, carrot slices were washed with tap water, surface moisture was removed by ambient air and then divided into 4 groups. There were 30 bags per group and the average weight was 50 ± 1g per bag. Carrot slices were packaged in 20 x 30 cm^2 PE bags with different number of perforations (3, 4 and 6). A vacuum packaging machine (Multivac, D-8941 Wolfertschwenden, Germany) was used to seal the packages keeping 6-7 % oxygen as the initial oxygen composition in the packs. Samples were vacuum packed served as control.

Storage

After packaging, all groups were stored at 5 °C for 12 days.

Measurements

Measurements were carried out on day 0 (before packaging), 4^{th}, 8^{th} and 12^{th} day during storage period. Ten packages from each group were removed from chamber at each interval.

Respiration, weight loss, oxygen concentration, firmness, surface color, pH and soluble solid content were measured at 20 °C during the experiment.

Respiration rate. Respiratory intensity as carbon dioxide production was measured for an hour in a closed respiratory system containing several hermetically closed plexi glass containers equipped with FY A600-CO2H carbon dioxide sensors connected to an Almemo 3290-8 data logger (Ahlborn Mess-und Regelungstechnik GmbH, Germany). Results were expressed in milliliter of CO_2 produced per kilogram of fruit in 1 h ($ml \cdot kg^{-1} \cdot h^{-1}$).

Oxygen concentration. The headspace oxygen concentration in the packages was determined by O_2/CO_2 gas analyser (ICA, UK) at each interval of storage. A small silicon septum was stuck to the packs and a needle was pierced into the package through this septum to draw the gas. The oxygen concentration value was displayed on the digital panel of instrument.

Weight loss. Carrot slices were weighed at day 0 and at each storage interval. The difference between initial and each storage period was considered as total weight loss during that interval and calculated as percentages on a fresh weight.

Surface color. Surface color of carrot slice was measured with a portable Minolta Chroma Meter CR-400 (Minolta Corporation, Osaka, Japan). CIE L*, a* and b* color characteristics were determined at the middle point of each slice. Results were expressed as whiteness index (WI) $[WI=100-[(100-L^*)^2+a^{*2}+b^{*2}]^{0.5}]$ and chroma value (CV) $[CV=(a^{*2}+b^{*2})^{0.5}]$, respectively, (Bolin & Huxsoll, 1991).

pH. pH was measured by a hand-held pH meter (Testo 206-pH1).

Firmness. Firmness of carrot slices was determined at the middle point of each slice, using Stable Micro System TA-XT Plus, UK.

Soluble solid content. Soluble solid content (SSC, %) was determined by a hand-held temperature-compensated ATAGO PAL-1 digital refractometer (Atago Co. Ltd., Tokyo, Japan).

Statistical analysis

All data were processed by SPSS (SPSS Inc, USA) using analysis of variance (ANOVA) with the factor: number of perforations (3, 4 and 6), followed by Tukey's method with a significance level of $P< 0.05$. The results were reported as a mean with standard deviations.

Results and discussion

Fig. 1 showed the change of oxygen concentration in the packages with different number of perforations. There was no difference in oxygen concentration among 3, 4 and 6 perforation packages. At the first 4 days, the oxygen concentration in the perforation packages increased rapidly from 6.5 % to around 20 % and remained in a similar range till the end of experiment. The oxygen concentration in the control samples (vacuum packaging) was below the detection limit during 12 days of storage.

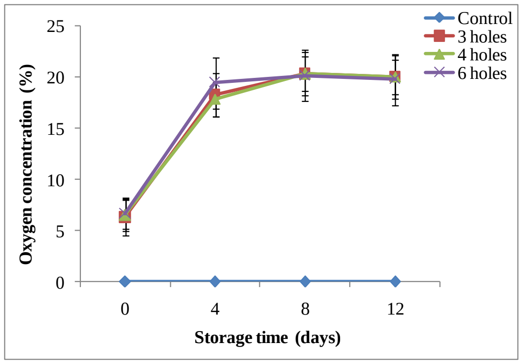


Fig. 1. Oxygen concentration in the packages during storage

The carbon dioxide production of carrot slices during storage was shown in Fig. 2. The respiration rate of all samples increased during storage period. No significant difference was detected among groups. Different number of perforations did not effect the respiration of carrot slices throughout 12 days of storage, compared to control (vacuum packaging).

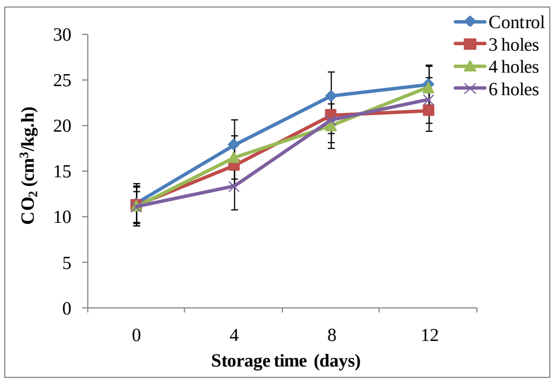
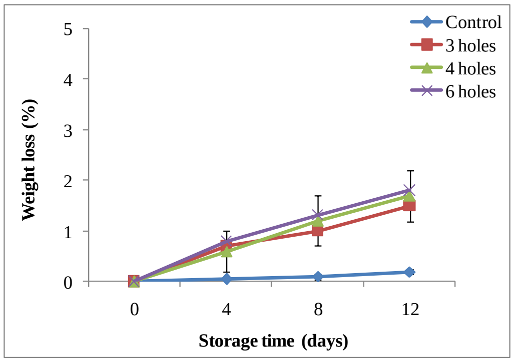
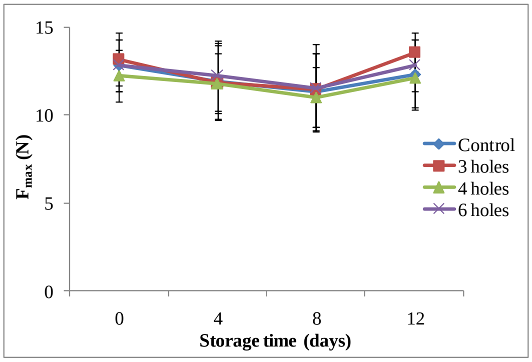


Fig. 2. Respiration of carrot slices

Weight loss of all samples occurring gradually as the storage time increased was shown in Fig. 3a. Almost no weight loss was observed for control samples at the first 4 days. The weight loss was negligible about 0.3 % for control sample whereas weight loss for perforated packs was much higher around 1.8 % at the end of experiment. Condensation of moisture was detected inside the perforated packages, in contrast no water was observed on the inner walls of control packs.



a)

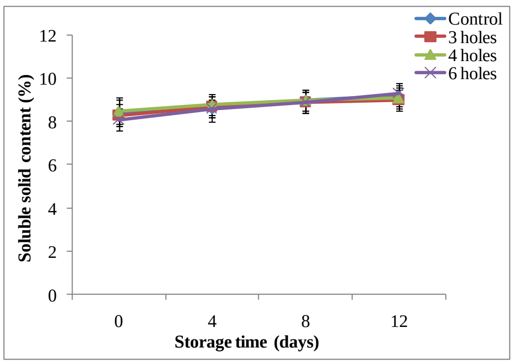


b)

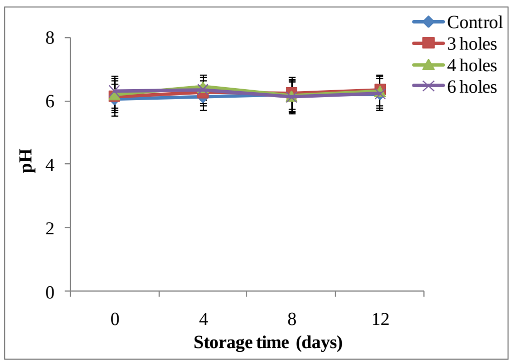
Fig 3. Weight loss (a) and firmness (b) of carrot slices during storage

In this work, the firmness was determined using the penetration force into carrot slices. Fig. 3b presented the changes in firmness of carrot slices during storage at 5 °C. The firmness decreased slightly throughout 8 days of storage and then increased. However, no significant difference was observed between groups and storage intervals. The decline of firmness at the first 8 days might be due to the natural ageing of commodity. Later on, the increase in firmness could result in moisture loss. It was in agreement with earlier reports of Dawange et al. (2016) for carrot slices, Klaiber et al. (2005) for shredded carrots. These authors found that the increase in firmness was because of dehydration and the beginning of lignifications throughout storage.

Total soluble solid of carrot slices increased slightly during storage, but no significant difference was observed compared to the initial time. There was no variation in soluble solid content among perforated groups and control (Fig. 4a).



a)



b)

Fig. 4. Soluble solid content (a) and pH (b) of carrot slices during storage

Similarly, the pH of all carrot samples remained steadily during storage (Fig. 4b). No significant difference was detected among groups.

The WI value of carrot slices increased during the first 8 days of storage then remained steadily till the end of experiment (Fig. 5a). The CV decreased throughout storage (Fig. 5b). It could be due to the formation of lignin during ageing. Our results were in agreement with previous report (Dawange et al., 2016).

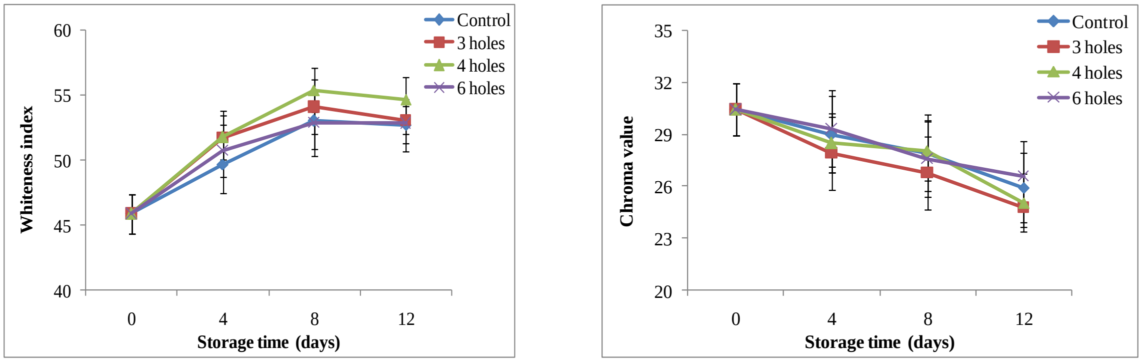


Fig. 5. Whiteness index (WI) and Chroma value (CV) of carrot slices during storage

Conclusion

The results of this experiment presented basic information about the effect of packaging material and the different number of perforations (3, 4 and 6) on quality of carrot slices during storage. There was no significant difference among perforated packages. Packages used in this study could maintain the quality of carrot slices for 12 days at 5 °C. However, achieving modified atmosphere was up to the quantity of product in the particular size of pack. Experiments evaluating the amount of commodity and number of holes are suggested for further research.

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