

Determination of the effects of refrigerated storage and packaging method on the instrumental textural attributes of fresh-cut carrot slices

B. Ergönül

Celal Bayar University, Engineering Faculty, Food Engineering Department, Muradiye Campus, Muradiye, 45140 Manisa, Turkey; bulent.ergonul@hotmail.com

Received: 10 January 2012 / Accepted: 16 March 2012

© 2013 Wageningen Academic Publishers

RESEARCH PAPER

Abstract

In this research fresh-cut carrot slices were packaged by three different techniques (passive modified atmosphere packaging, modified atmosphere packaging and vacuum packaging), stored at 4 ± 1 °C for 9 days and instrumental textural attributes (hardness and toughness) of carrot samples were determined at three-day intervals. As a result of the study, it was found that hardness values of the samples which were passive modified atmosphere packaged and vacuum packaged significantly increased during storage ($P<0.05$).

Keywords: instrumental textural attributes, minimal processed carrot, modified atmosphere packaging

1. Introduction

Minimal processed foods are defined as the foods having high nutritional value, are ready to use (or eat), delicious and keep their freshness for a long time (Rico *et al.*, 2007). It is thought that minimal processing like sorting, cutting and peeling adds value to the product before being distributed and marketed for consumption (Vina and Chaves, 2003). But, degradative changes can occur during processing and these products are known as highly perishable (Vina and Chaves, 2003).

On the other hand, sensorial changes are significantly linked to tissue deterioration during minimal processing of the food (Toivonen and Brummell, 2008). One of the most important sensorial characteristics of processed fruits and vegetables is known as texture. Many researchers indicated that instrumental textural measurements, especially hardness measurement, is important in terms of quantifying and determination of product quality (Vu *et al.*, 2004). For an extended shelf life, fruits and vegetables can be packaged under modified atmosphere or vacuum in order to prevent the loss in quality attributes (Farber *et al.*, 2003). From that point of view, in this study, it was aimed to determine

the textural attributes of carrot slices packaged by using different packaging methods during refrigerated storage.

2. Materials and methods

Daily fresh carrots (averagely 20 cm in length and 4 cm in diameter) were purchased from a local market. They were washed under tap water and sorted. Residual water was removed and carrots were cut into pieces having a thickness of 10 mm. Carrot pieces were divided into five different groups for packaging by using different methods. One group of carrot pieces were packaged aerobically under passive modified atmosphere (air) (PA). The second group was packaged under modified atmosphere containing 50% CO₂ and 50% N₂ (ECN). The third and fourth group were also packaged under modified atmosphere containing 25% CO₂ and 75% N₂ (LCHN) and 75% CO₂ and 25% N₂ (HCLN), respectively, whereas the final group was vacuum packaged (VP). Packaging machine (Henkelman Vacuum System, 's-Hertogenbosch, the Netherlands) equipped with a gas mixer (Witt-Gasetechnik, Witten, Germany) was used for packaging the carrot samples. Linear low density polyethylene material (O₂ permeability 4,050 cm³/m²/atm/day, CO₂ permeability 14,000 cm³/m²/atm/day) was used for packaging for each batch of samples. Dimensions of the

package material were 200 mm and 150 mm, whereas the thickness of the package was 50 µm. Package materials were purchased from Artı Packaging (İzmir, Turkey). Packaged samples were kept at 4±1 °C for 9 days and instrumental textural attributes of the samples were determined on packaging day and during storage at 3 days intervals.

For determination of the instrumental textural attributes of the samples, TA.XT Plus Texture Analyzer (Stable Micro Systems, Ltd, Godalming, UK) was used. Thickness of the samples was 10 mm, whereas the diameter was 20 mm. For determination of toughness of the samples, a Warner-Bratzler blade (Stable Micro Systems Ltd., Godalming, UK) with a gap of 42 mm was used (Lin *et al.*, 1998; Rastogi *et al.*, 2008). The test speed was 0.5 mm/s. The area under the peak was calculated and named as toughness (N.s).

On the other hand, a cylindrical probe (Stable Micro Systems Ltd., Godalming, UK) having a diameter of 35 mm (P35) was used for determination of hardness values of the samples. The load was 50 kg, whereas the test speed was 1 mm/s and the strain was 30% (Araya *et al.*, 2007). Data acquisition rate was 200 pixels per second and two compressions in a row were applied on the samples to determine hardness. Hardness (N) is the maximum height of the first peak on the first compression. According to the graphic obtained, instrumental textural profile attributes of the samples were determined according to Szczesniak (1963), Szczesniak (1966) and Bourne (1978).

Findings obtained from the analyses were evaluated by the GLM procedure of the SAS statistical analyses programme according to the completely randomized design (SAS, 2001). Duncan analysis was applied on the results found statistically significant ($P<0.05$) (Sante and Fernandez,

2000). All experiments were repeated twice and for each replicate three measurements were taken for a batch.

3. Results and discussion

Average hardness values of the samples can be seen in Table 1. Average hardness score of carrot samples on the day of packaging (day 0) was 352.5 N. As can be seen in Table 1, on the 3rd day of the refrigerated storage, the average hardness score of PA samples was 373.6 N, whereas it was found to be 422.8 N on the 6th day and 463.7 N on the 9th day. This increase in hardness score of PA samples was found significantly important ($P>0.05$).

On the 3rd day of the storage hardness values were 384.6 N, 380.9 N, 420.9 N and 448.7 N for ECN, LCHN, HCLN and VP samples. There were no significant differences observed among hardness values of the samples packaged by different techniques on the 3rd day of the storage ($P>0.05$). On the 6th and 9th days of the storage, hardness values were determined as 358.3-381.4 N, 377.5-386.5 N, 378.0-465.9 N and 313.2-397.4 N respectively for ECN, LCHN, HCLN and VP samples. Also it was observed that hardness of vacuum packaged carrot slices increased significantly during refrigerated storage ($P<0.05$).

As can be seen from Table 1, the initial average toughness value of carrot samples was 1,954.7 N.s. On the 3rd day of the storage average toughness scores of the samples PA, ECN, LCHN, HCLN and VP were 1,913.4 N.s, 2,146.0 N.s, 1,865.5 N.s, 2,207.9 N.s and 1,943.6 N.s, respectively. On the 6th day of the storage these values were 2,107.5 N.s, 2,074.6 N.s, 2,078.0 N.s, 2,042.7 N.s and 2,113.1 N.s, respectively for the same samples. Average toughness score of the sample PA was determined as 2,380.3 N.s on the 9th

Table 1. Instrumental textural attributes of minimally processed carrot samples packaged by different methods during storage at 4±1 °C.

Sample \ Day	Toughness (N.s)				Hardness (N)				
	0	3	6	9	0	3	6	9	9
PA	1,954.7 ^B	1,913.4 ^B	2,107.5 ^{AB}	2,380.3 ^A	352.5 ^B	373.6 ^B	422.8 ^{ABa}	463.7 ^A	
ECN	1,954.7	2,146.0	2,074.6	2,087.3	352.5	384.6	358.3 ^{ab}	381.4	
LCHN	1,954.7	1,865.5	2,078.0	2,262.2	352.5	380.9	377.5 ^{ab}	386.8	
HCLN	1,954.7	2,207.9	2,042.7	2,133.9	352.5	420.9	378.0 ^{ab}	465.9	
VP	1,954.7	1,943.6	2,113.1	2,331.4	352.5 ^{AB}	448.7 ^A	313.2 ^{Bb}	397.4 ^A	

ECN = packaged under modified atmosphere containing 50% CO₂ and 50% N₂; HCLN = packaged under modified atmosphere containing 75% CO₂ and 25% N₂; LCHN = packaged under modified atmosphere containing 25% CO₂ and 75% N₂; PA = packaged aerobically under passive modified atmosphere; VP = vacuum packaged.

Values within a row with different superscript capital letters are significantly different from each other ($P<0.05$).

Values within a column with different superscript small letters are significantly different from each other ($P<0.05$).

day of the storage. As a result of the statistical analyses, it was determined that storage period significantly affected the average toughness score of the samples PA. Toughness score of PA significantly increased during refrigerated storage ($P < 0.05$), whereas average toughness values of the other samples did not increase significantly during storage ($P > 0.05$). As can be seen from Table 1, on the 9th day, the average toughness scores of ECN, LCHN, HCLN and VP were 2,087.3 N.s, 2,262.2 N.s, 2,133.9 N.s and 2,331.4 N.s, respectively.

As a result of the instrumental textural analyses of the samples packaged by using different methods, it was concluded that by using modified atmosphere packaging, textural attributes of minimal processed carrot slices could be kept without any significant changes during refrigerated storage for 9 days.

References

- Araya, X.I.T., Hendrickx, M., Verlinden, B.E., Buggenhout, S.V., Smale, N.J., Stewart, C. and Mawson, A.J., 2007. Understanding texture changes of high pressure processed fresh carrots: a microstructural and biochemical approach. *Journal of Food Engineering* 80: 873-884.
- Bourne, M.C., 1978. Texture profile analysis. *Food Technology* 32: 62-66, 72.
- Farber, J.N., Harris, L.J., Parish, M.E., Beuchat, L.R., Suslow, T.V., Gorney, J.R., Garrnett, E.H. and Busta, F.F., 2003. Microbiological safety of controlled atmosphere and modified atmosphere packaging of fresh and fresh-cut produce. *Comprehensive Reviews in Food Science and Food Safety* 2: 142-160.
- Lin, M.T., Durance, T.D. and Scaman, C.H., 1998. Characterization of vacuum microwave, air and freeze dried carrot slices. *Food Research International* 31: 111-117.
- Rastogi, N.K., Nguyen, L.T. and Balasubramaniam, V.M., 2008. Effect of pretreatments on carrot texture after thermal and pressure-assisted thermal processing. *Journal of Food Engineering* 88: 541-547.
- Rico, D., Martin-Diana, A.B., Barat, J.M. and Barry-Ryan, C., 2007. Extending and measuring the quality of fresh-cut fruit and vegetables: a review. *Trends in Food Science and Technology* 18: 373-386.
- Sante, V. and Fernandez, X., 2000. The measurement of pH in raw and frozen turkey *Pectoralis superficialis* muscle. *Meat Science* 55: 503-506.
- SAS, 2001. Statistical analysis programme. SAS, Cary, NC, USA.
- Szczesniak, A.S., 1963. Classification of textural characteristics. *Journal of Food Science* 28: 385-389.
- Szczesniak, A.S., 1966. Texture measurements. *Food Technology* 20: 55-58.
- Toivonen, P.M.A. and Brummell, D.A., 2008. Biochemical bases of appearance and texture changes in fresh-cut fruit and vegetables. *Postharvest Biology and Technology* 48: 1-14.
- Vina, S.Z.A. and Chaves, A.R., 2003. Texture changes in fresh cut celery during refrigerated storage. *Journal of the Science of Food and Agriculture* 83: 1308-1314.
- Vu, T.S., Smout, C., Sila, D.N., Nguyen, B., Van Loey, A.M.L. and Hendrickx, M., 2004. Effect of preheating on thermal degradation kinetics of carrot texture. *Innovative Food Science and Emerging Technology* 5: 37-44.

