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# Ascorbic Acid Treatments For Preventing Lignification On Ready-To-Use Carrot

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**Abstract**

Carrot was consumed by people due to benefits to human health. Carrots are best known for their rich supply of the antioxidant nutrient that was actually named for beta-carotene. However, these delicious root vegetables are the source not only of beta-carotene, but also of a wide variety of antioxidants and other health-supporting nutrients. Trends to use fresh-cut product increased nowadays, because humans wants to consume fruit and vegetables freshly. In this research, the effect of different doses ascorbic acid treatments to shredded-carrots to prevent lignification was studied. For this aim, carrots were obtained from the Kocaeli Wholesale Distribution Center, and were screened for uniformity, such as being free from any mechanical damage and diseases and also same sized. After washing, carrots were shredded and treated with 1, 2 and 4% ascorbic acid to prevent lignification and to extend shelf life. Excessive ascorbic acid over carrot surface dried in a salad spinner for 60 second, and then carrots were packaged in a plastic box. Carrots were stored in a cold room at 4±1°C temperature and 85-90 RH during 14 days. Color values, whiteness index, visual quality scores of samples and softenin index values were determined at the begining and 7 days intervals during storage. L values of samples treated with 4% ascorbic acid were higher than the other treatments, and followed by 2% and 1% ascorbic acid and control group. The same findings were obtained by a* and b* values of samples. Lignification of fresh-cut carrot occures in the form of surface whitening. But in the present study, whitening which is signs of lignification did not seen on shredded carrot surface. So, it was found that ascorbic acid treatment to shredded carrots prevented to lignification. But firmness loss occured ascorbic acid treated samples compared to control group. Therefore, it is suggested that ascorbic acid and firming agent must be used together for shredded carrot to prevent both lignification and softening in the future work.

***Key words:*** Carrot, shredded, lignification, colour, storage

**Kullanıma Hazır Havuçlarda Lignifikasyonun Engellenmesi için Askorbik Asit Uygulamaları**

**Özet**

Havuç, insan sağlığına faydaları nedeniyle insanlar tarafından tüketilmektedir. Havuç antioksidan besin maddelerince özellikle beta-karoten açısından zengin bir kaynak olarak bilinmektedir. Bununla birlikte, bu lezzetli kök sebzesi, yalnızca beta-karoten kaynağı değil aynı zamanda çok fazla miktarda diğer antioksidanları ve sağlığı destekleyici besin maddelerini içermektedir. Günümüzde insanlar meyve ve sebzeleri taze olarak tüketmek istediği için taze-kesilmiş ürün kullanımına olan eğilimler artmaktadır. Bu araştırmada, rendelenmiş havuçlarda lignifikasyonu önlemeye yönelik olarak, farklı dozlarda askorbik asit uygulamalarının etkisi araştırılmıştır. Bu amaçla, havuçlar, Kocaeli Toptancı Hal'inden temin edilmiş ve kullanılmadan önce bir örneklik, mekanik hasar ve hastalıklardan arilik ve büyüklük açısından incelenmiştir. Havuçlar yıkama işleminden sonra rendelenmiş ve lignifikasyonu önlemek ve raf ömrünü uzatmak için, 1, 2 ve% 4 askorbik asit ile muamele edilmiştir. Havuçların yüzeyindeki askorbik asitin fazlası, salata kurutucu kullanılarak 60 saniye süre ile kurutulmuş ve daha sonra havuçlar plastik bir kutuda paketlenmiştir. Paketlenmiş havuçlar 14 gün süreyle 4±1°C sıcaklık ve 85-90 oransal nemde soğuk odada muhafaza edilmiştir. Depolama başlangıcında ve depolama süresince 7 gün aralıklarla renk değerleri, beyazlık indeksi, görsel kalite puanları ve yumuşama indeksi belirlenmiştir. % 4 askorbik asit uygulanmış örneklerin L değerleri, diğer uygulamalara göre daha yüksek olmuş ve bu uygulamayı %2 ve %1 askorbik asit uygulaması ile ve kontrol grubu izlemiştir. Benzer sonuçlar, a* ve b* renk değerlerinde de elde edilmiştir. Taze kesilmiş havuçlarda lignifikasyon kesim yüzeyelerinde beyazlatma şeklinde oluşmaktadır. Ancak bu çalışmada, rendelenmiş havuç yüzeyinde lignifikasyonun işareti olan beyazlama gözlenmemiştir. Dolayısıyla rendelenmiş havuçlarda askorbik asit uygulaması lignifikasyonu engellendiği bulunmuştur. Fakat askorbik asit uygulanmış örneklerde, kontrol grubuna göre sertlik kaybı olmuştur. Bu nedenle, rendelenmiş havuçlarda hem lignifikasyon hem de yuşumaşamayı önlemek için askorbik asit ve sıkılaştırıcı bir maddenin birlikte kullanılması gerektiği önerilmektedir.

**Anahtar Kelimeler*:*** Havuç, askorbik asit, taze-kesilmiş, lignifikasyon, renk, depolama.

**Introduction**

Carrot (*Daucus carota* L.) is a popular root vegetable, grown and consumed throughout the world. It is the source of many nutrients contained in it due to biologically active compound such as beta-carotene. Carrot is the source not only of beta-carotene, but also of a wide variety of antioxidants and other health-supporting nutrients.

Ready-to-use (RTU) root vegetables are typically peeled, sliced, diced or shredded prior to packaging. Slicing cuts through cells, leaving large areas of internal tissue exposed. It also distrupts some sub-cellular compartmentalization, bringing previously separated enzymes and substrates together, such physical damage also leads to leakage of cell contents during subsequent storage (Barry-Ryan and O'Beirne 1998), and also cause many undesirable changes during storage and distribution that must be controlled to maintain quality (Izumi and Watada 1994).

Surface discoloration and total moisture loss may also be increased by the nature and extent of tissue exposure (Watada 1994). Stress response reactions lead to increased respiration rates and the synthesis of lignin, and also may increase the rate of physiological ageing. Both dehydration (Cisneros-Zevallos et al. 1995) and lignin synthesis (Bolin and Huxsoll 1991) have been implicated in the surface whitening of cut carrot tissue.

Once carrots are exposed to air, they easily dehydrate, and dried cell debris acquires a whitish color, forming a white layer on the carrot surface. At this stage, the quality defect reversed by dipping carrots in water and allowing for rehydration (Cisneros-Zevallos et al. 1995). As the lignification process is enzyme mediated, some dipping treatments directed to inactivate the responsible enzymes have been tested. A successful result was obtaiend with a treatment combinin heat inactivation and an acidic environment. Carrots peeled with coarse sandpaper and dipped for 20-30 sec. in a 2% citric acid solution at 70°C did not develop the defect for at least five weeks in cold storage; product taste was not affected by the treatment (Bolin and Huxsoll 1991). Citric acid dips of 1 mM or higher concentration reduce respiration rate of shredded carrots by 50% or more (Kato-Noguchi and Watada 1997).

Edible film have also been shown to protect carrots from this quality defect (Sargent et al. 1994). Sensory results showed preference for carrots coated with an edible cellulose-based coating due to a fresh appearance (Howard and Dewi 1995), because consumer perceive white blush carrots as not fresh or aged.

Ascorbic acid (Vitamin C) is a reducing agent often used to prevent oxidation reactions such as browning; however, there may be effects on other physiological processes in the cut tissues (Toivonen and DeEll 2002). Ascorbic acid dips reduced the respiration of "Fuji" apple slices stored in a 0% $O_2$ atmosphere (Gil et al. 1998). In air atmosphere, the ascorbic acid dips reduced ethylene production and increased the respiration of apple slices.

The objective of this study was to determine the effects of ascorbic acid treatments on lignin formation of ready-to-use carrot shreds.

**Materials and Methods**

**Plant Material**

Carrots were obtained from Kocaeli Wholesale Distribution Center. After that, carrots were immediately brought to the laboratory, and screened for uniformity which is being free from any mechanical damage and diseases, and also same stage of maturity. Then carrots peeled and simultaneously trimmed of tap root and stem plate prior to sample preparation. A grater was used to prepare carrot shreds.

**Sample Preparation**

Processed carrots (100g for each replicate) were dipped in 3 L solution of 1% Ascorbic acid (AA), 2% AA, 4% AA or distilled water (control, C) for 90 sec. at room temperature. Treated carrot shreds were dried for 2 min at room temperatire using a salad spinner to remove surface solution.

**Packaging and Storage Conditions**

A 100 g shredded RTU carrot was placed in a plastic box with cover, and stored in a cold room at 4±1°C temperature and 85-90 % relative humidity for 14 days.

**Color Measurement**

Color measurements (L*, a* and b* values) were performed using a chromameter CR-400 (Konica Minolta Inc. Osaka, Japan) with illuminant D65 with 8 mm aperture. The instrument was calibrated with a white reference tile (L*=97.52, a*=-5.06, b*=3.57) prior to measurements. The L* (0=black, 100=white), a* (+red, -green) and b* (+yellow, -blue) color coordinates were determined according to the CIELAB coordinate color space system.

Whiteness index (WI, Eq. (1)), was calculated using measured L*, a* and b* values as follows and used to determine the color changes as compared with control of ready-to-use carrot shreds (Sarıçoban and Yılmaz 2010)

$$\mathrm{WI} = 100 - \sqrt{(100 - \mathrm{L}*)^2 + \mathrm{a}*^2 + \mathrm{b}*^2} \quad \text{Eq. (1)}$$

**Visual Quality Assessment**

Visual quality was evaluated with reference to freshness, appearance, color, uniformity and brightness in a 5-points scale as follows: 5-Excellent; 4-Good quality, minor defects; 3-Fair quality, slightly to moderately objectionable defects; 2-Poor quality, excessive defects; 1-Extremly poor quality, not usable.

**Softening Assessment**

Softening of carrot shreds was scored as a subjectively, according to that hardness or softness feeling perceived when carrots taken between two fingers and pressure is applied. For this aim or 5-points scale was used as follows: 5- vey hard; 4-hard, 3-partially hard/soft, 2-Soft, 1-Very soft (not usable)

**Statistical Analysis**

Experiments were conducted in acompletely randomized design with a minimum of-three replications per storage treatments per sampling date. Data were analyzed by ANOVA and differences among means were determined by the Duncan's multiple range test with significance level at p<0.05.

**Results**

**L* Colour Values of RTU carrot shreds**

L* colour values of samples were high at the begining of storage (Fig. 1), but it was decreased at the 7th day in samples in control, 1% AA and 2% AA treatments. At the day 14, L* values of samples treated with 4% AA were higher than that of other AA treatments and control groups, and differences among the treatments were found to be statistically significant (P<0.05).

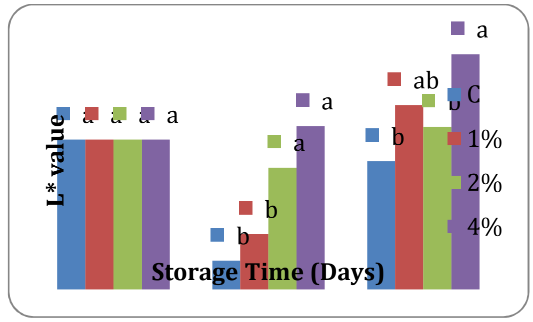


Figure 1. L* values of shredded carrots treated with different doses of ascorbic acid (AA).

**a* Colour Values of RTU carrot shreds**

Similarly L* values, a* colour values of ready-to-use carrot shreds decreased at the day of 7, according to initial L* values of storage in all treatment groups (Fig. 2). a*values of samples treated with 4% AA were found to be high compared to the other treatments both 7th and 14th day of storage, and also differences between 4% AA treatment and the other treatments were statistically significant at P<0.05 level. At the end of the storage a* values of samples in 4% AA treatment were high (30.05), and was followed by 1% AA (28.50), 2% AA (27.77) and C (24.63).

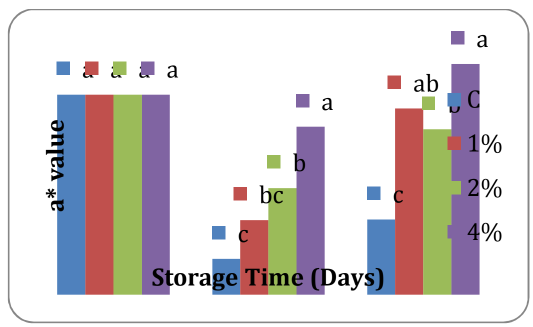


**Figure 2.** a* colour values of shredded carrots treated with different doses of AA.

**b* Colour Values of RTU carrot shreds**

In Fig. 3, shows b*values of ready-to-use carrot shreds treated with different doses of ascorbic acid. Whereas b* values of the other treatment groups decreased dramatically (36.05, 36.65 and 37.46. for C, 1% AA and 2% AA respectively), it was exactly the same values of initial values of storage in 4% AA treated samples (46.00), and differences between 4% AA treatment and the other treatments were statistically significant. b*values of samples in C (38.84), 1% AA (41.13) and 2% AA (39.89) treatments were increased however the highest values were obtained in samples of 4% AA treatment (43.77) at the day 14.

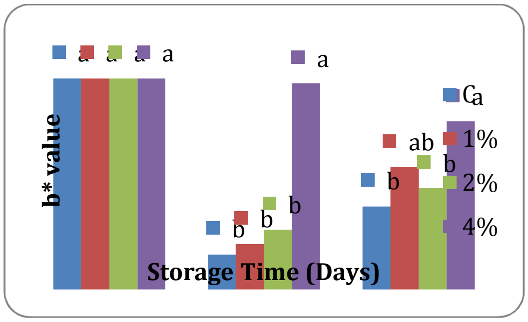


**Figure 3.** b* values of ready-to-use carrot shreds treated with different doses AA.

**Whiteness Index (WI) of RTU carrot shreds**

Whiteness index (WI) of samples in all treatment groups were low at the begining of storage, and then increased in all treatment groups during storage (Fig. 4). At the day 7, the lowest WI was obtained by carrot shreds treated with 4% AA, and followed by C, 1% AA and 2% AA treated samples, respectively. In this period, carrot shreds treated with 2% AA has the highest WI values. It is found that WI values of samples in control group are increased whereas it decreased in samples treated with ascorbic acid in all doses at the end of the storage period.

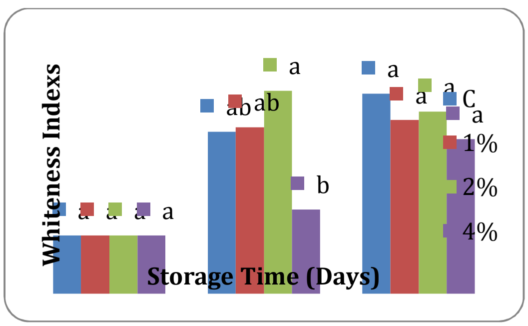


**Figure 5.** Whiteness Index of ready-to-use carrot shreds treated with different doses ascorbic acid (AA).

**Visual Quality Scores**

Visual quality scores of samples in all treatment groups are given in Fig. 5. Visual quality scores of samples in all treatment groups were decreased at the day 7, and it is fallen down initial scores. At the day 7, visual guality scores of carrot shreds treated with ascorbic acid in all concentration increased compared to control group. But differences among the treatments was not significant statistically (P<0.05). Visual quality scores of samples treated with 4% ascorbic acid determined to be the highest at the end of the storage periods, and followed by the treatments of 2% AA, 1% AA and control group . Also, the differences between 4% AA treatment and the other treatment group were found to be significant statistically at P<0.05 level.

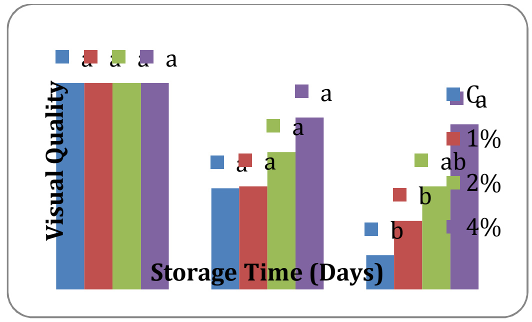


**Figure 5.** Visual quality scores of ready-to-use carrot shreds, treated with different doses of AA.

**Softening Index of Carrot Shreds**

Hard texture's of control group was maintained during storage, but the tissue of samples treated with ascorbic was softened (Fig. 6) at the end of the storage. Also, the differences between control group and samples in treated with ascorbic acid in all doses is found to be significant statistically at P<0.05 level.

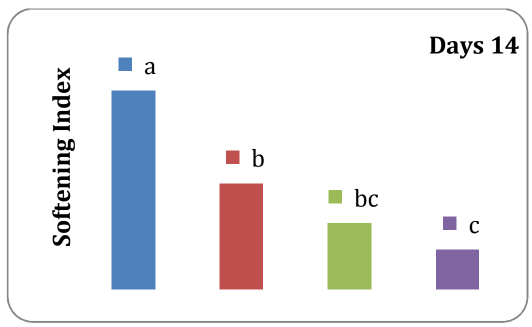


**Figure 6.** Softening index of ready-to-use carrot shreds, treated with different doses of AA at the day 14.

**Discussions**

The bright orange colour of fresh carrot can disappear in stored fresh-cut products, particularlıy when abrasion peeling is used. Carrots may develop “white blush”, also known as “white bloom”, a discoloration defect that results in formation of a white layer of material on the surfaze of peeled carrots, giving a poor appearance to the product. As the lignification process is enzyme mediated, some dipping treatments directed to inactivate the responsible enzymes have been tested. A successful result was obtaiend with a treatment combinin heat inactivation and an acidic environment.

The effect of ascorbic acid treatments on surface colour of carrot shreds was positive while is negative on texture. Based on chroma value, it is observed surface colour of ready-to-use carrot shreds, treated with ascorbic acid, was more brighter than control group during storage. But surface colour of samples in control group faded, and it was observed L* values of samples was decreased at the day 7. L* values of control group then was increased at the end of storage but it was not extent initial scores. L values of carrots shreds treated with different doses of ascorbic acid was increased during storage, in the CIELAB system, it is indicated that if L value is zero colour of samples is white, and if L value is hundred, colour of samples is dark (Voss 1992). Therefore, lower L* values of control group is sign of white tissue formation on the carrot shreds.

In this experiment, a* and b* colour values of samples treated with ascorbic acid were high while control group's low. So, it can be said that surface color carrot shreds was retained with ascorbic acid treatments, especially higher doses. Ascorbic acid (Vitamin C) is a reducing agent often used to prevent oxidation reactions such as browning; however, there may be effects on other physiological processes in the cut tissues (Toivonen and DeEll 2002). As results of present work, it is found that ascorbic acid treatments were inhibited white color formation on carrot shreds surface.

White tissue formation was not seen on the surface of samples treated with ascorbic acid, and also whiteness index values of carrot shreds was found to be low compared to control group, and at the day 7, the whiteness index of the control group, 1% and 2% ascorbic acid-treated samples was increase dramatically. But whiteness index of samples treated with 4% ascorbic acid were low than other treatments. Thus, it was declared that ascorbic acid treatments especially higher doses were prevent white tissue formation on shredded carrot surface.

The appearance of product is one of the most important criteria of quality. The value of fresh-cut fruits and vegetables to the costumer is determined by the quality posses. The quality of a product is a combination of an array of parameters, including appearance, texture, flavor and nutritional value. Also, consumers judge the quality of fresh-cut fruits and vegetables on the basis of appearance and freshness at the time of purchase (Barry-Ryan et al,.2007). As shown in visual quality scores, carrot shreds treated with ascorbic acid has brighter, more fresh, good appearance than those of control group.

Although ascorbic acid treatments prevent white tissue formation on surface of shredded carrot, it is caused tissue softening. With regard to results of softening index, it is found that the firmness of samples in control group was retained best, whereas it is softening samples in ascorbic acid treatments.Therefore, it is suggested that for preventing of white tissue formation with ascorbic acid will be used together with a firming agent.

**Conclusions**

Surface tissue of ready-to-use carrot shreds has white color caused by peeling and cutting of carrot. This discoloration is increased when carrot shreds subjected air. White layer of the carrot surface giving a poor appearance. Stress response reactions lead to increased respiration rates and the synthesis of lignin, and also may increase the rate of physiological ageing. As the lignification process is enzyme mediated, some dipping treatments directed to inactivate the responsible enzymes. For this aim ascorbic acid was used in this study. Ascorbic acid treatments was inhibited lignification also called whitening on carrot shreds surface, but this treatments increased firmness losses. Therefore, it is suggested that for preventing of white tissue formation with ascorbic acid will be used together with a firming agent such as $CaCl_2$ in the future works.

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