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Vapor Heat Treatment Increase Quality and Prevent Chilling Injury of Cucumbers (*Cucumis melo* L. cv. Silor)

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Abstract: Fruits of cucumber when stored below 7°C for a long duration have showed chilling injury (CI) symptoms. Vapor heat treatment is a method of heating fruit with air saturated with water vapor at temperatures of 40-50°C to kill insect eggs and larvae as a quarantine treatment before fresh market. Cucumber fruits (cv. Silor) were treated vapor heat at 48°C for four different times: 2 min (VH_1), 4 min (VH_2), 6 min (VH_3) or 8 min (VH_4) and fruits had no treated with vapor heat assessed as control (C). After vapor heat treatments fruits were stored at 4°C temperature and 85-90% relative humidity conditions during twelve days. The vapor heat treatment at 48°C for 8 min (VH_4) reduced electrolyte leakage and softening of fruits and maintained a* values and hue angle (h°) values of fruits at 4°C of storage time. The VH_4 treatment however reduced weight and total soluble solids (TSS) of fruits compared to other vapor heat and control fruits while the visible quality of fruits retain best of fruits in VH_4. Therefore, it could be said that VH_4 treatment produced highest quality due to prevent electrolyte leakage, reduce softening and maintain green color of fruits.

Key words: Cucumber (*Cucumis melo* L. cv. Silor) · Vapor heat · Electrolyte leakage · Firmness · Total soluble solids · Color

INTRODUCTION

Storage of cucumber fruits (*Cucumis sativus* L.) at temperatures lower than 10°C causes chilling injury (CI) [1]. Using temperatures close to 0°C could not only prolong the duration of the fruits, but also lead to the development of physical treatments that replace chemical insecticides for fruits. The effect of temperature is related to its direct effect on lowering fruit respiration, ethylene production and fruit metabolism in general [2]. However, for several tropic and subtropical commodities, chilling temperatures can be detrimental. The sensitivity of different commodities constitutes a limitation for storage and transport for durations at low temperatures.

Chilling injury may develop if cucumbers are stored at lower temperatures, as characterized by surface pitting and dark watery patches. This injury is generally followed by an increased tendency to decay, particularly when the temperature is raised. The postharvest life of cucumbers usually does not exceed 2-3 weeks and is limited by physiological deterioration of the fruit related decay caused by CI [3].

Heat treatments such as hot water dip, vapor heat, hot dry air or combinations of these have been increasingly used as a quarantine treatment in several studies to retard post-harvest fungal damage to fruits and vegetables [4].

Vapor heat is a method of heating fruit with air saturated with water vapor at temperatures of 40-50°C to kill insect eggs and larvae as a quarantine treatment before fresh market [5]. Vapor heat was developed spesifically for insect control, but hot air has been used for both fungal and insect control and to study the response of commodities to high temperature. Bard and Kaiser [6] found that heat treatments in a selection of fruit have been disinfesting of fungal and bacterial rots; de-sensitizing fruit to chilling injury; reducing incidince of post-harvest physiological disorders; decreasing rate of ripening and prolonging shelf life.

The aim of this work was to study the impact of vapor heat treatments on quality (color, firmness and total soluble solids) and also on prevent chilling injury symptoms assesed by an electrolyte leakage during storage.

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MATERIALS AND METHODS

Plant Material: Cucumbers (*Cucumis sativus* L. cv. Silor) were freshly harvested from a farm in Kocaeli, Turkey. The cucumber fruits used for treatments were selected by uniform size and free from blemishes.

Storage Conditions and Treatments: Before packaging, cucumbers were divided into four lots for vapor heat treatments. Treatments used were: Control (non-treated with vapor heat, C), vapor heat treatments at 48°C temperature for 2 min (VH_1), 4 min (VH_2), 6 min (VH_3) or 8 min (VH_4) respectively. After vapor heat treatments, all cucumber fruits were removed to ambient room temperature (20°C) for cooling before storage. After cooling, three cucumber fruits with three replicate per treatment were placed into polystyrene foam dishes and wrapped polyethylene stretch film, then fruits were stored at 4°C temperature and 85-90% relative humidity conditions for 12 days.

Electrolyte Leakage (El): Electrolyte leakage was measured as fruit discs (5 mm diameter) cut out of fruit. The discs were washed several times in distilled water and then incubated in distilled water. Conductivity was measured after 2h of incubation. Total electrolyte conductivity in the discs was measured after they had been frozen and thawed. EL was calculated as the percentage of the conductivity after 2 h out of total.

Firmness: Firmness of fruits was measured using a firmness tester, Pressure Tester Model with 8 mm plunger. For the flesh firmness cucumbers were cut in two portions and flesh firmness was determined at the center of each part of fruit.

Total Soluble Solids (TSS): For TSS (°Brix) the samples were measured with a Hand-held "Pocket" refractometer and expressed as a percentage. For the juice, fruits of cucumber cut in two part and fruit juice was obtained squeezed of fruit by hand. Three fruits were used for each replicate.

Color Measurements: The color attributes L*, a*, b* and C of two opposite sides of each cucumber in each replicate were measured using a chroma meter (Model CR-400, Conica-Minolta, Osaka, Japan). The first side of the cucumber measured was the upper side, followed by the lower side of the packages. The hue angle (h°) was calculated as $h°=\tan^{-1}(b/a)$, when a>b and b>0 or as $h°=180°-\tan^{-1}$ when a<0 and b<0.

Fresh Weight Loss: Cucumbers belongs three replicates of per treatment were weighed before storage and 3th, 6th, 9th and 12th days of storage. Weight loss was calculated as percentage difference of the initial weight.

Statistical Analysis: The data was subjected to one-way analysis of variance and the differences among the treatments were analysed using Duncan's multiple range test ($p<0.05$). Each treatment was composed of 3 replicate polystyrene foam dishes and three samples for each dish were used for measurements.

RESULTS AND DISCUSSION

Electrolyte Leakage (El): The electrolyte leakage (EL) expressed as a percent of total EL was between 24.84% and 28.65% first three days of storage and progresively increased with increased treatment time from 2 to 6 min and extended storage periods from 3 to 12 days. Also, the EL of tissue discs fruit from in all treatments were increased with storage time regardless of treatments (Fig 1). But, EL rates samples of 8 min. vapor heat treatment (VH_4) were lower than fruits in all treatments of vapor heat and control group at the 9th day of storage. The differences between VH_4 treatment and the other treatments were significant ($p<0.05$). This decrease in EL suggest that 8 min. vapor heat treatment was prevent chilling injury (CI) because increased EL is associated with appearance of CI symptoms in many sensitive plant tissues [7].

Also, in cucumbers have high rates of ion leakage are associated with cell damage due to chilling injury [8] as well as other types of stresses. At the end of the storage, EL rates were differed among vapor heat treated fruits and the highest values were detected in fruits treated at 2 min heat (45.80%) and followed by VH_2 (45.00%), VH_3 (42.40%), control (40.07%) and VH_4 (34.13%), respectively. DeEll *et al.* [3] (2000), reported that irreversible membrane injury due to chilling injury requires at least 7 d at 4.0°C (chilling temperature) in cucumber. The results presented here are in agreement with those of DeEll *et al.* [3] since significant changes in membrane permeability were not evident until 6th day of storage. After this time, EL was increased both fruits in control and in vapor heat treatments except VH_4. In fruits treated vapor heat for 8 min. had lower electrolyte leakage than in control and

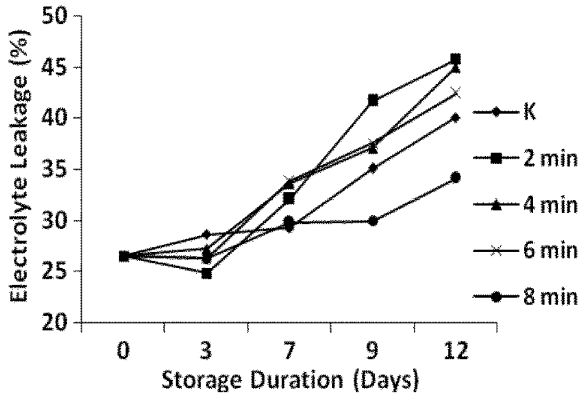

Fig. 1: Changes of electrolyte leakage of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

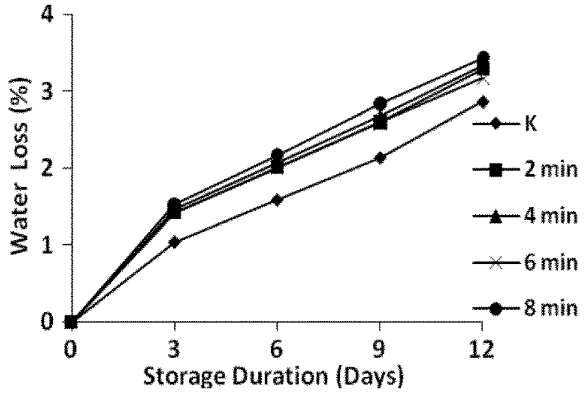

Fig. 2: Changes in water loss of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

other vapor heat treatments, so it appears that the effectiveness of vapor heat treatment is related to application time. Also it could be said that, in our study, VH_4 treatment was the most effective treatment for prevent chilling injury than the other vapor heat treatments and control.

Water Loss: Water loss is a critical factor shortening of storage life and increasing deterioration of many fruit during storage [9, 2]. In the present study, fruit weight (water loss) in vapor heat treatments were effected by treatment duration. Fruit weight decreased gradually with storage time during storage and VH_4 fruits (3.44%) showed slightlly higher weight loss than control (2.97%) and VH_3 (3.17%), VH_1 (3.29%) or VH_2 (3.33%) respectively (Fig. 2) at the end of storage.

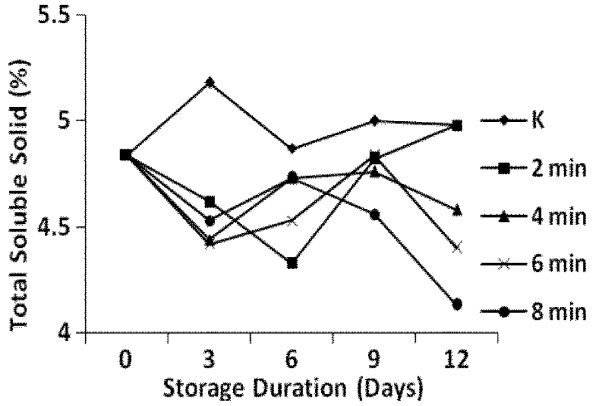

Fig. 3: Changes in total soluble solids (TSS) of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

According to Peleg [10], fruits and vegetables deteriorate when they lose more than ~3% to 10% of their weight causing significant wilting, softening and shrivelling. In present study, weight loss of fruit until 9th day of storage was less than 3% but after that time it exceed 3% particularly in vapor heat treated fruits. It is common that fresh horticultural produce exhibit greater weight loss at higher storage temperature because of the increase in vapor pressure at high temperature [11]. It was noted in our study that cucumber fruits treated vapor heat showed more weight loss at lower temperature. The increase in weight loss at low temperature might be related to development of CI through cellular breakdown, deterioration of membrane integrity as well as loss of epicuticular wax which is important in water exchange through cucumber fruit skin [8].

Total Soluble Solids (TSS): The TSS of cucumber fruits was highest in control group and vapor heat treatments caused significant changes ($p<0.05$) between TSS during the first three days of storage time (Fig 3). TSS of fruits at this time ranged between 5.18% and 4.42%. TSS content of fruits variable during storage period but it was tended to remain between 4.13% and 4.98% at the end of the storage. Also, some differences in soluble solids were observed at different intervals in the storage period but these differences were not systematic. Therefore, a clear effect of the vapor heat treatments on soluble solids content of stored cucumbers could not be established. However, it was suggested that TSS in vapor heat treated cucumbers was lower than in control fruits during storage and it was lowest in fruits of VH_4 (4.13%) and followed by

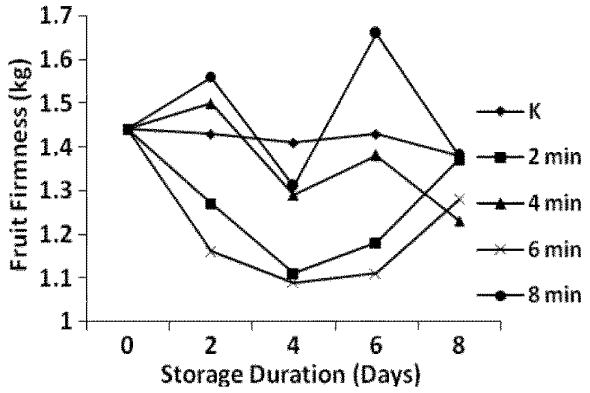

Fig. 4: Changes in fruit firmness of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

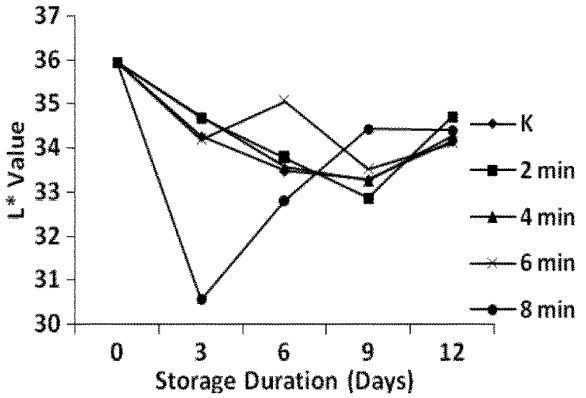

Fig. 5: Changes in L* values of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

VH_3 (4.40%), VH_2 (4.58%), VH_1 (4.98%) or control (4.98%) respectively. So it could be said that the decrease of TSS in fruits of vapor heat treatment may be depends on incresing metabolism caused by vapor heat. Sajnin *et al.* [12] reported, total soluble solids content of 2.3°Brix on fresh cucumbers of unspecified cultivar, so TSS content of cucumbers both control and vapor heat treatments higher than this value.

Fruit Firmness: The firmness of fruit was reduced on cucumber fruits in all treatment groups during the storage. The firmness value was higher in control fruits (1.41 kg) during first six day of storage and followed by VH_4 (1.31 kg), VH_2 (1.29 kg), VH_1 (1.11 kg) or VH_3 (1.09 kg) respectively and also differences between VH_1, VH_3 and control VH_2, VH_4 were statistically significant (Fig. 4). The same trend was obtained at the 9th day of storage, however, firmness of fruits in all treatments was decreased at the end of the storage and there were no significant differences among the treatments. Fruit firmness is one of the criteria of fruit quality determined by various researchers for different fruits. Also, firmness is one of the components of texture which is a complex sensory attribute that also includes crispiness and juiciness [13] and is critical in determining the acceptability of horticultural commodities [14]. In present study fruit firmness of fruits in all treatments was decreased during storage but this decrease was not dramatically. So, the acceptability of fruits was maintained good (data not shown) particularly in control and in VH_4 treatments. Vapor heat treatments did not have noticeable effect of softening except for VH_4 treatment.

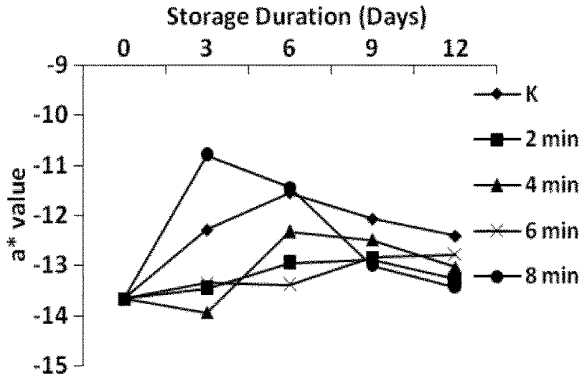

Fig. 6: Changes in a* values of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

Color Changes: L* values measured on "Silor" cucumber fruits ranged from 30.56 to 34.70 (Fig 5), a* values from -10.81 to -13.94 (Fig. 6) and b* values from 14.89 to 20.57 (Fig. 7) units at the 3th day of storage.

The hue angle (Fig. 8) of fruits ranged from 124.0-126.27 which reflected green color of the fruits. At the end of the storage skin color changed more in control fruits (Fig. 6) and followed by vapor heat treatments but, there was found no significant differences among the treatments.

In all treatments L* and C* values of cucumber fruits in all treatment groups (Fig. 9) were decreased over 12 days at 4°C. The hue angle was changed very little during the storage, but it was maintained high in VH_4 treatment compared to the other applications. Therefore, in fruits in VH_4 green color was maintained. Also, this result was correlated with a* values of fruit treated with 8 min. vapor heat. Wang [15] reported that peel color change of fruit

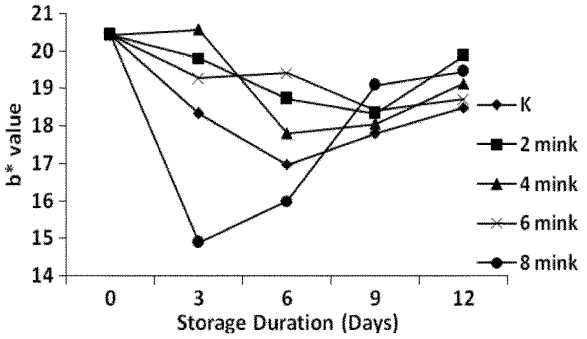

Fig. 7: Changes in b* values of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

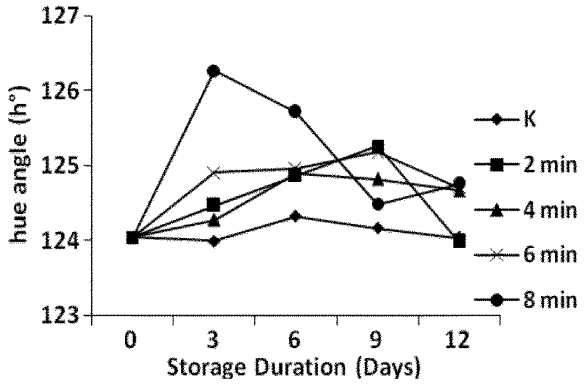

Fig. 8: Changes in hue angle values of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

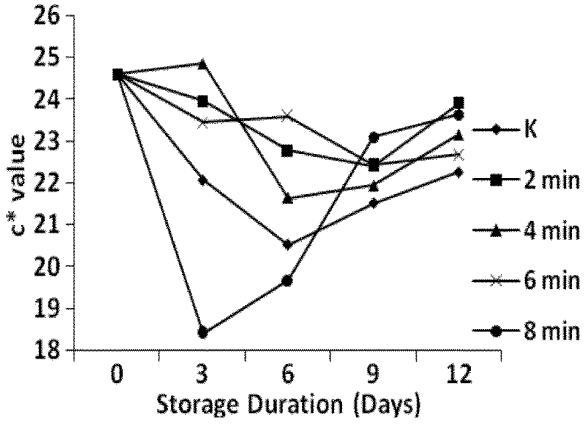

Fig. 9: Changes in c* values of cucumber fruits after vapor heat treatment and 4°C temperature and 85-90% relative humidity conditions during storage

correlated with chlorophyll degradation. Gong and Mattheis [16] and Trebitsh *et al.* [17] suggested that breakdown of chlorophyll causes degreening of plant organs during ripening and senescence and that ethylene plays an important role in stimulating chlophyllase activity. In present study, a values and hue angle values of fruits in control were slightly high decreased during storage compared to vapor heat treatments, especially VH_4. Also, EL values of fruit treated with 8 min. vapor heat were lower than the other vapor treatments and than in control groups. Therefore, vapor heat treatments particularly 8 min. were delayed fruit senescence due to prevent chilling injury during storage at 4°C.

CONCLUSIONS

The vapor heat treatments with "Silor" cucumber fruits temperature at 48°C for 8 min and storage temperature at 4°C 12 days were demonstrated to maintain appearance and peel color index of fruits. Electrolyte leakage (EL) and firmness of fruits were maintained by 8 min vapor heat treatment at the end of the storage compared to the other vapor heat treatments. The vapor heat treatment for 8 min (VH_4) however reduced weight and total soluble solids content of fruits. The other vapor heat treatments had no noticiable effect on quality criteria of cucumbers.

REFERENCES

1. Suslow, T. and M. Cantwell, 1997. Cucumber: Recommendations for maintaining Postharvest quality. www.postharvest.ucdavis.edu.
2. Hardenburg, R.E., A.E. Watada and C.Y. Wang, 1986. The Commercial Storage of Fruits, Vegetables and Florist and Nursery Stocks. United States Department of Agriculture, Agricultural Research Service. Agricultural Handbook. pp: 66.
3. DeEll, J.R., C. Vigneault and S. Lemerre, 2000. Water tempeature for hydrocooling field cucumbers in relation to chilling injury during storage. Postharv. Biol. Technol., 18: 27-32.
4. Mansour, F.E., S.A. Abd-El-Aziz and C.A. Helal, 2006. Effect of fruit heat treatment in three mango varieties on incidence of postharvest fungal disease. J. Plant Pathol., 88: 141-148.
5. Le, T.N., C.C. Shiesh and H.L. Lin, 2010. Effect of vapor heat and hot water treatments on disease incidence and quality of Taiwan native strain mango fruits. Int. J. Agric. Biol., 12: 673-678.
6. Bard, Z.J. and C. Kaiser, 1996. Post-harvest vapor heat shock treatments of Fuerte avocado fruit. South African Growers' Assoc. Yearbook, 19: 116-118.

7. Saltveit, M.E. and L.L. Morris, 1990. Overview of chilling injury of horticultural crops. pp: 3-15. In. CY Wang (ed.) Chilling injury of horticultural crops. CRC Press, Boca Raton FL.
8. Hakim, A., A.C. Purvis and B.G. Mullinix, 1999. Differences in chilling sensitivity of cucumber varieties depend on storage temperature and the physiological dysfunction evaluated. Postharv. Biol. Technol., 17: 97-104.
9. Ben-Yehoshua, S., 1989. Individial Seal Packaging of Fruit and Vegetables in Plastic Film. In: Brody, AL (Ed.) Controlled/Modified Atmosphere/Vacum Packaging of Foods. Food and Nutrition Press, Inc. Trumbell, Connecticut, pp: 101-119.
10. Peleg, K., 1985. Produce, Handling, Packaging and Distribution. AVI Pub. Co.Inc. Westport CT.,
11. Martínez-Romero, D., M. Serrano and D. Valero, 2003. Physiological changes in pepino (*Solanum muricatum* Ait.) fruit stored at chilling and non-chilling temperatures. Postharv. Biol. Technol., 30: 177-186.
12. Sajnin, C., G. Gamba, L.N. Gerschenson and A.M. Rojas, 2003. Textural, histological and biochemical changes in cucumber (*Cucumis sativus* L.) due to immersion and variations in tugor pressure. J. Sci. Food Agric., 83: 731-740.
13. Konopacka, D. and W.J. Plocharski, 2003. Effect of storage conditions on the relationship between apple firmness and texture acceptability. Postharv. Biol. Technol., 32: 205-211.
14. Abbott, J.A. and F.J. Harker, 2004. Texture. The Commercial Storage of Fruits, Vegetables and Florist and Nursery Stocks. United States Department of Agriculture, Agricultural Research Service. Agricultural Handbook Number 66. http://www. ba. ars. usda.gov./hb66/021texture.pdf
15. Wang, C.Y., 1977. Effect of aminoethoxy analogs of rhizobitoxine and sodium benzoate on senescence of broccoli. Hort. Sci., 12: 54-56.
16. Gong, Y. and J.P. Mattheis, 2003. Effect of ethylene and 1-methylcyclopropene on chlorophyll catabolism of broccoli florets. Plant Growth Regul, 40: 33-38.
17. Trebits, T., E.E. Goldschmidt and J. Riov, 1993. Ethylene induces de novo synthesis of chlorophyllase, a chlorophyll degrading enzyme in citrus fruit peel. Proc. Natl. Acad. Sci. USA, 90: 9441-9445.