Bulgarian Journal of Agricultural Science, 16 (No 6) 2010, 678-686
Agricultural Academy

EFFECTS OF MODIFIED ATMOSPHERE PACKING AND ETHANOL TREATMENT ON QUALITY OF MINIMALLY PROCESSED TABLE GRAPES DURING COLD STORAGE

F. K. SABIR, A. SABIR* and Z. KARA
Selcuk University, Agricultural Faculty, Horticultural Department, 42070 Konya, Turkey

Abstract

SABIR, F. K., A. SABIR and Z. KARA, 2010. Effects of modified atmosphere packing and ethanol treatment on quality of minimally processed table grapes during cold storage. *Bulg. J. Agric. Sci.*, 16: 678-686

During the past few years, minimally processing industry worldwide has grown rapidly. So far, a number of studies were conducted on extending the postharvest quality of processed commodities. However, literature investigations on minimally processed grapes revealed that limited publications is available. This study was conducted to investigate the effect of modified atmosphere packaging (MAP) and ethanol treatments on quality maintenance of stemless grapes *cv*. 'Muskule' (*V. vinifera* L.). The grape berries were stored at 0±1°C for 4 weeks and assessed weekly intervals to determine the changes in quality characteristics. All the treatments helped to minimize the quality loss of berries in varying degrees, while untreated berries lost their marketable quality around the 3rd week. The taste of the berries was not impaired by applications during storage. MAP was superior in most cases such as restriction of weight loss, and maintenance of berry appearance in comparison with ethanol. Ethanol also helped to preserve the overall quality of stemless berries during storage, although it was ineffective in prohibiting the loss in weight. On the other hand, the use of MAP together with ethanol exhibited the best results in maintenance of overall quality parameters. Therefore, the use such combination shows promise to extend the quality of minimally processed grapes in cold storage.

Key words: grape, minimal processing, ethanol, weight loss, berry decay

Introduction

Turkey is the sixth country in grape production with its annual production around 3 600 000 ton (Anonymous, 2007). About 27% of grapes produced in Turkey are sold as table grape (Uzun and Bayir, 2008). However, an important quantity of table grape is lost at various stages from harvest to markets. Minimizing the losses of grapes is more sustainable and environmental mean than extending the vineyards to compensate for wastages. So far, interdisciplinary strategies for attaining such aims worldwide promoted valuable advances in postharvest technology for long term maintenance of the quality of fresh grapes to prevent postharvest wastages. Minimal processing (fresh-cut) of produces greatly reduces the wastage of produces. Due to many other advantages compared to corresponding intact forms of products, minimal processing sector have grown rapidly during the past decade, extending from the foodservice sector to the retail shelf.

*Corresponding author: asabir@selcuk.edu.tr

However, processed produces generally have a more complicated physiology (Kader, 2002) which causes difficulties in handling. Probably due to this handicap, limited information is available regarding postharvest quality or physiology of processed grapes in literature, although a number of studies were conducted on the preservation of postharvest quality of grapes using intact clusters (Kou et al., 2007).

Worldwide studies in postharvest extension of table grapes still rely on the methodology based on sulphur dioxide (SO_2) applications owing to its excellent responses to control decay (Soylemezoglu, 2001). Although the postharvest application of fungicides was considered to be an effective method for decay control of fruits during storage, it is not a suitable technology for table grapes, due to their brittle pericarp and succulent flesh. Moreover, the use of SO_2 is becoming restrictive as its residues are dangerous to people allergic to sulphites and may cause injuries to the commodities. Thus present interest focuses on the use of healthy materials with simple and sustainable technology. Many studies on SO_2 replacement were conducted on various cultivars using tools such as hot water (Fallik, 2004), modified atmosphere packaging, controlled atmosphere (Eris et al., 2000), ethanol (Lichter et al., 2002), chlorine dioxide (Ahvenainen, 1996; Soliva-Fortuny and Belloso, 2003), carbonate/bicarbonate salts, pulsated ultraviolet, ozone, and chitosan (a natural polysaccharide) (Xu et al., 2007), although none of them was perfect. Studies show that dipping grapes in 30-50% ethanol prior to packaging effectively inhibited berry decay (Lichter et al., 2002; Karabulut et al., 2004; Gabler et al., 2005). Also, Del Nobile et al. (2008) investigated the influence of various treatments (ethanol, chlorinated water and hot water) on the quality loss kinetics of freshly processed grapes. They suggested that ethanol was the best solution to preserve the microbial stability of the fresh produce. Crisosto et al. (2000) also indicated that the use of ethanol dipping could be well adapted when the stemless berry packaging was considered.

Extending the postharvest life of the minimally processed table grapes necessitates knowledge of all the factors that lead to quality loss, as well as the use of this knowledge to develop affordable strategies for minimizing deteriorations, as processing accelerates the respiration rates, resulting in more rapid loss of biochemical components (Ergun et al., 2008). Therefore, increased O_2 demand of processed product dictates that packaging films with regulation of internal O_2 and CO_2 concentrations is essential issue to maintain the fresh state. Modified Atmosphere Packaging (MAP) was developed to regulate CO_2 and O_2 concentrations by using plastic liners with different gas perm abilities in conjunction with fruit respiration at a given temperature (Kader, 2002), although insufficient when used alone. Recently dipping in solutions of natural compounds in combination with modified atmosphere packaging (MAP) was proven as promising means for postharvest control decay (Valero et al., 2006). The aims of present study were (a) comparative evaluation of MAP and ethanol dip and (b) investigation of their combined applications on maintaining the qualities of minimally processed (stemless) berries of grape cultivar Muskule (*Vitis vinifera* L.).

Material and Methods

Preparation of grape samples

Clusters of table grapes (*Vitis vinifera* L., cv Muskule) at commercial maturity (17.7° Brix SSC and 0.43% acidity) were harvested from a vineyard located in Konya/Turkey. The samples were then transported to the laboratory. The rachis of the grapes was manually removed (Kou et al., 2007) to obtain stemless berries. The stemless berries were then sorted to ensure homogeneous batches based on colour, size, and the absence of blemishes or disease. Berries were then washed with tap and distilled water successively to remove residues. After allowing the surface moisture for evaporation, the berries were distributed randomly in four groups for applications.

Treatments and study design

The berries for ethanol application were completely submerged in 30% ethanol solution while the control group was dipped into distilled water for 5 min. MAP was performed to samples treated with ethanol or water. To allow evaporation of water on berry sur-

face, all berries were kept at the room temperature with a mild air movement for about 20 min. For each treatment, three replications containing 250 g of berries were packaged in a 12× 15 cm rigid polypropylene cylinder cups. Treatments were (a) sealing with a film (29.2 pmol/s/m^2/Pa oxygen transmission rates) as control, (b) modified atmosphere packaging (MAP), (c) ethanol dip (30%), and (d) ethanol plus MAP. The packages were stored at 0±1 °C with a relative humidity of 90% for quality evaluation performed with weekly intervals. For each treatment, three cups were analyzed in weight loss, soluble solids content (SSC), pH, titratable acidity (TA), maturity index (TSS/TA), decay analyses, berry appearance, and sensory tests weekly. The study was planned to cease when the overall quality of the berries were around the critical threshold of commercial acceptability.

Quality evaluation

Berry weight loss was calculated as percentage with comparing to initial weights of each replicate. SSC (°Brix) was determined with a hand-held temperature-compensated refractometer (Atago 9313). TA (expressed as a percentage of tartaric acid) was quantified by titrating 10 mL of the homogenized berry flesh juice (must) with 0.1N NaOH to an endpoint of pH 8.1. All assays were performed in triplicate. Berry appearance was performed with a visual scales of 1 to 5 were used (1 very dry, brown, and brittle; 2 dry and brown; 3 dry and brownishgreen; 4 green and partially dry; and 5 green and fresh) (Gabler et al., 2005).

Decay analysis

Percentages of decayed berries were calculated separately by dividing the number of grapes in each package showing visible decay symptoms by the total number of grapes in that package and multiplying the dividend by 100 (Valero et al., 2006).

Sensory analysis

The changes in organoleptic quality of stemless grape berries were further investigated by a trained panelist tests including 10 members, according to the procedures described by Reitmeier and Nonnecke (1991). The members were trained in a pretest in which berries with extremely low or high attributes were used (Martinez-Romero et al., 2003). The panellists were asked to consider the quality attributes especially sweetness, crispness, taste and undesirable odour while judging the samples during analysis. For analyses, an individual booth for each panellist was used in a laboratory. A grading scale for this test panel was established as follows; 1 bad, 2 not acceptable, 3 good, 4 very good and 5 excellent (exactly as the freshly harvested grapes). The panellists were briefly instructed to cleanse their mouth with distilled water, chew the random berry samples, and evaluate the sample using the values between 1 and 5 (Guillen et al., 2007).

Statistical analysis

Data sets from analyzed parameters were subjected to analysis of variance (ANOVA). Sources of variation were time of storage, treatments, and their interactions. Comparisons of means were performed by Turkey's multiple range tests at different significance levels. All analyses were preformed with SPSS software package ver. 15.0 for windows.

Results and Discussion

Quality assessment

Evaporation of intercellular water during the storage is the main factor responsible for direct loss in weight (Wills et al., 1998) and ultimate quality of grapes. The effect of different treatments on weight loss changes of Muskule berries during the storage is presented in Figure 1. The rate of weight loss increased with the storage time at 0°C. MAP with or without ethanol treatments significantly ($P<0.0001$) retarded the loss in weight and the weight loss values of these treatments were lover than 0.4%. Such delay in weight loss may be attributed to the effect of MAP on decreasing the respiration rate of fruits (Kader, 2002) and on restriction of malate dehydrogenase (MDH) activity (Ke et al., 1995), one of the most active enzymes involved in certain metabolic pathways

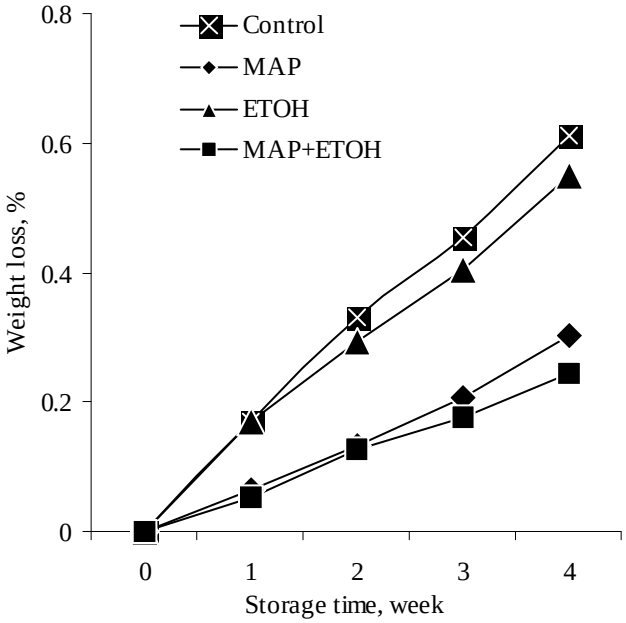

Fig. 1. Weight loss changes of minimally processed grape berries during the storage. Each point represents the mean of three replicates (LSD for application: 0.017)

that result in senescence of fruit tissues (Sacher, 1973). From such physiological perspective, the essential role of low O_2 and high CO_2 levels of MAP appears to be related solely with its restrictive impact on the activities of enzymes responsible for respiration. MAP is also proven as a good water vapour barrier and is able to maintain a relative humidity inside the pack (Philips, 1996). This attribute helped to retard the moisture content of stemless berries. On the other hand, there was no significant difference between control and ethanol treatment regarding weight loss, indicating the ineffectiveness of ethanol on restraining the moisture inside the berry.

Initial SSC content of grape berries was 17.7º Brix. SSC levels in all treatments progressively increased along with the prolonged storage, probably due to water loss and the slow ripening process occur in berries although the grape is a nonclimacteric fruit (Figure 2). After 4 week storage, effects of treatments on SSC change was found significant ($P<0.0025$). All applications inhibited the increase in SSC, in varying degrees, as previously indicated (Sabir et al., 2006; Sabir et al., 2008). Non-treated berries presented a greater increase in SSC level, reaching to peak value of 19.2º Brix, while combined effect of both MAP and ethanol treatments on delaying the SSC change was obvious, with the value of 18.2º Brix.

The effects of treatments on TA change during the storage were insignificant. However, TA levels in overall berries apparently decreased during the storage (Figure 3). This is in general agreement with the results of various studies conducted on different cultivars such as Sultanina (Athanasopoulos and Thanos, 1998), Thompson seedless (Crisosto et al., 2002) and Superior seedless (Artes-Hernandez et al., 2006). The gradual decrease in acid level during the storage may physiologically be attributed to increase in membrane permeability allowing acids stored in cell vacuoles to be respired and transformation of acids to sugars (Winkler et al., 1974; Sabir et al., 2010) besides certain other processes occur inside the cells. Therefore, reduction in tartaric acid level might influence solely the activity of many enzymes involved in respiratory metabolism, ethylene biosynthesis and compositional changes of berries. Such mechanisms essentially in-

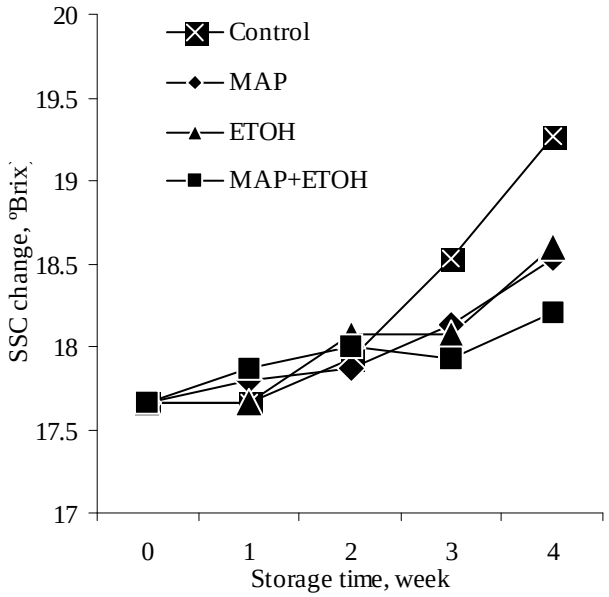

Fig. 2. SSC changes of minimally processed grape berries during the storage. Each point represents the mean of three replicates (LSD for application: 0.145)

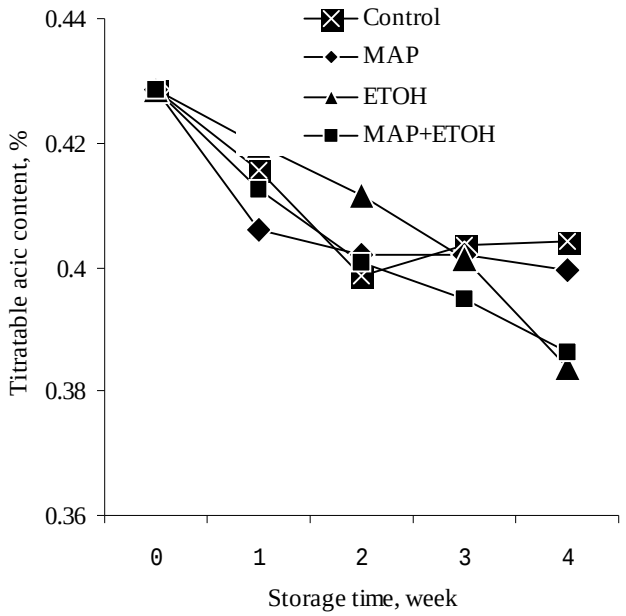

Fig. 3. Titratable acid changes of stemless grape berries during the storage. Each point represents the mean of three replicates

fluence postharvest life of horticultural products.

As regards berry quality, it is widely accepted that one of the most important parameters determining consumer acceptability of table grapes is the ratio between SSC and TA (maturity index). Maturity index at harvest was 41.1 and slightly increased with storage time (Figure 4) although the magnitude of this change was insignificant. After 4 week storage, SSC/TA values were between 46.4 (MAP) and 48.4 (ethanol). Such increments in SSC/TA were widely indicated in previous reports (Kader, 2002; Sabir et al., 2006) while Crisosto et al. (2003) asserted the ineffectiveness of such treatments on SSC/TA. In fact, literature investigations revealed that the findings on the effects of treatments on SSC/TA level, exhibit quite differences. Such divergent results might arise from different environmental conditions in which the experiment cultivars were grown as well as cultivar aptitude regarding the convenience to cold storage.

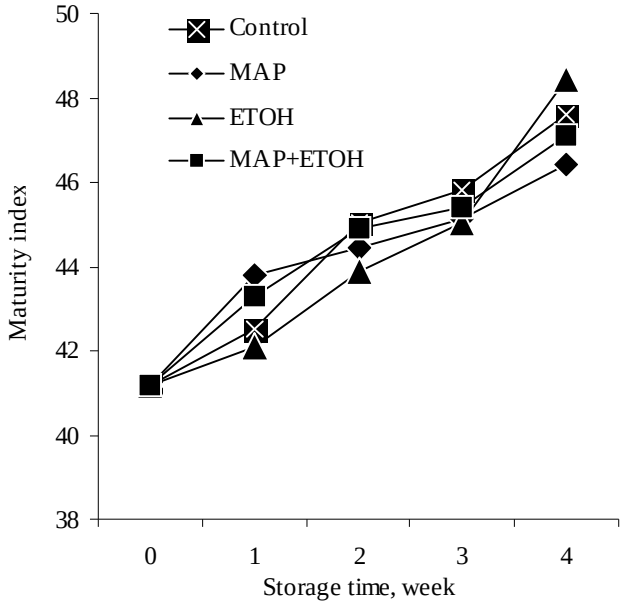

Fig. 4. SSC/TA (maturity index) changes of minimally processed grape berries during the storage. Each point represents the mean of three replicates

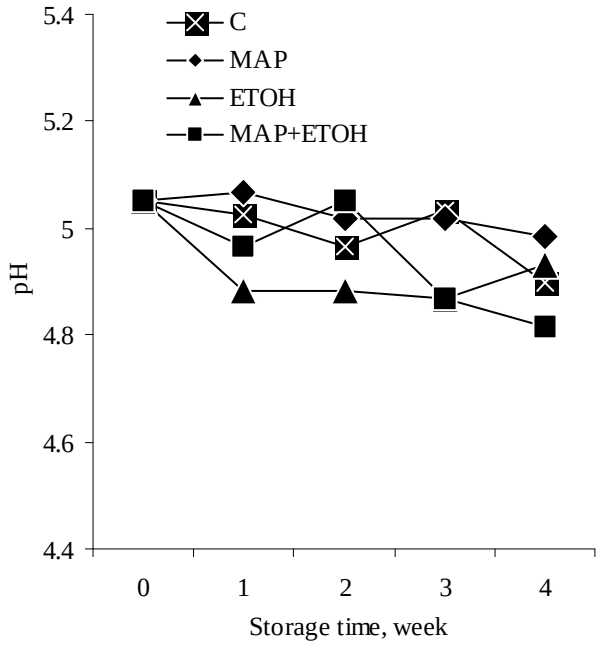

Fig. 5. pH changes of minimally processed grape berries during the storage. Each point represents the mean of three replicates

Although statistically insignificant, slight decreases in pH value in general berries were determined (Figure 5), with similar manner occurred in TA levels. Treatments did not affect pH changes during storage as previously indicated in several studies (Takeda et al., 1983; Sanchez-Ballesta et al., 2006; Sanchez-Ballesta et al., 2007).

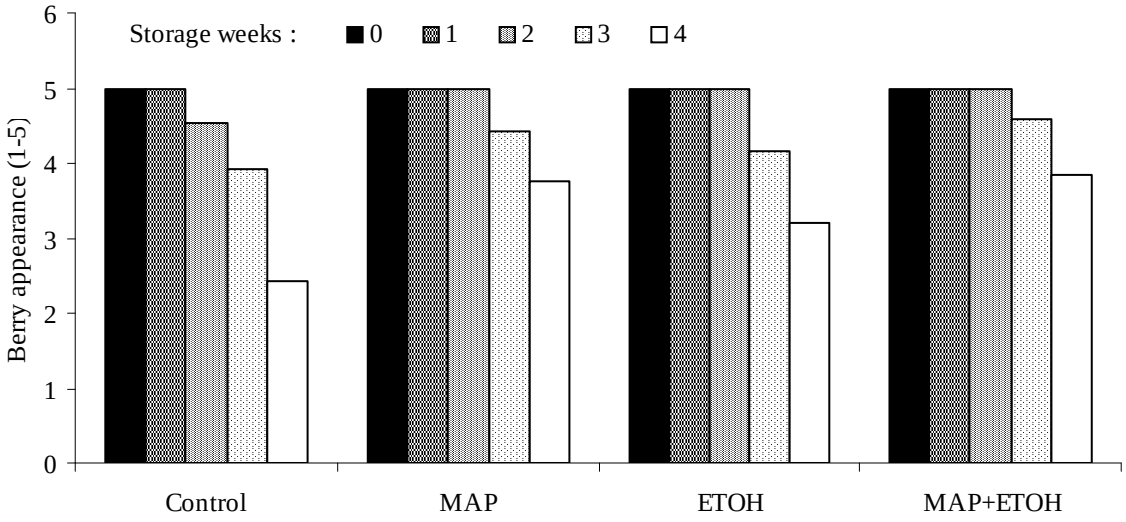

Fig. 6. Berry appearance score of stemless grape berries during the storage (LSD for application: 0.131)

In extending postharvest quality of produces consumer acceptability is a prime consideration. Up to the 3rd week of the storage period, almost no change occurred in berry appearance, except for control where little reduction was detected. However, the berries underwent noticeable decreases in berry appearance around the 3rd and 4th weeks (Figure 6). At the end of the storage, the control berries with a least berry appearance value of 2.4 were not marketable due to shrivelling and decay development on berry surface, whereas the overall appearances of the berries stored under MAP conditions with or without ethanol dip were significantly ($P<0.0001$) better than those of control. The effect of MAP on maintenance of initial berry appearance, likely resulting from its capability on moisture retention with convenient gas permeability (Philips, 1996), was obvious. Ethanol alone was not as effective as MAP to preserve berry appearance when storage time was prolonged up to 4 weeks. Ethanol dip treatment therefore may supposedly render the berries more susceptible to water loss, deteriorating the intact wax which predisposes the berry to microorganism infection (Brummell et al., 2004; Deytieux et al., 2007). Studies revealed that a minimum loss in water content may sharply affect berry appearance of table grapes, leading to browning, wilting and shrivelling (Cappellini et al., 1986; Crisosto and Mitchell, 2000). In deed, the highest changes in berry appearance were observed in control and etha-

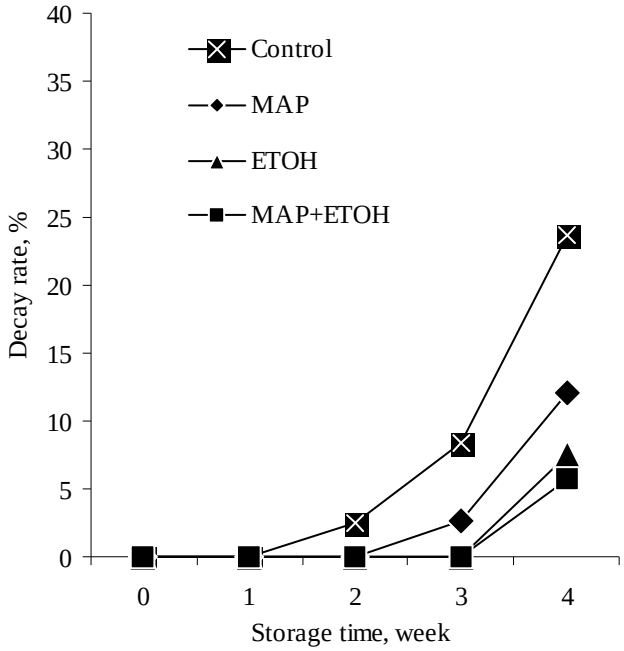

Fig. 7. Decay rate of stemless grape berries during the storage. Each point represents the mean of three replicates (LSD for application: 0.279)

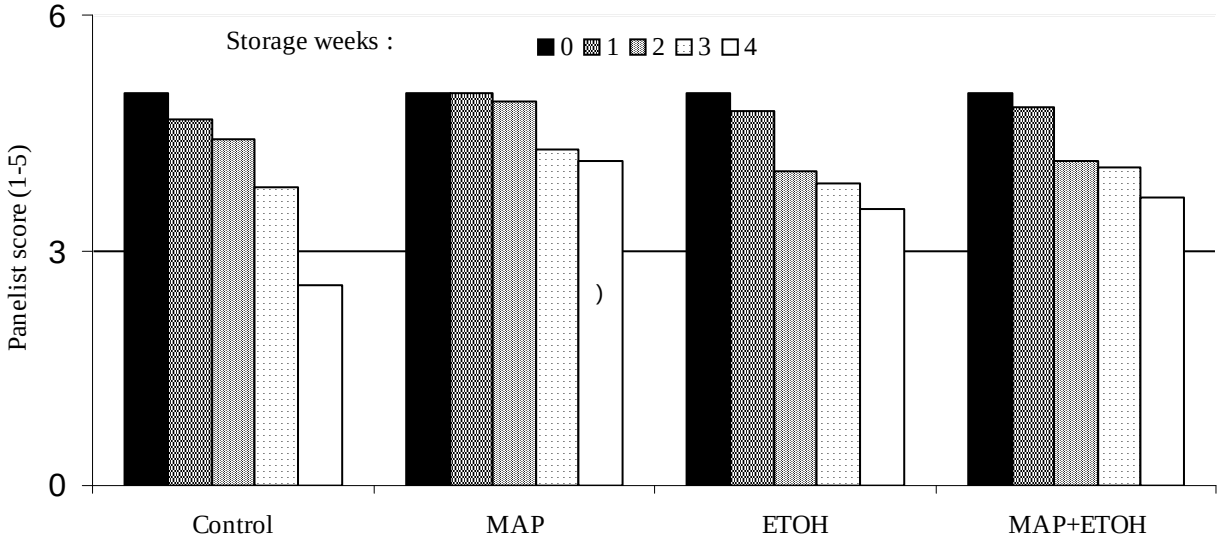

Fig. 8. Sensory analysis score of stemless grape berries during the storage (LSD for application: 0.112)

nol-treated berries, in a similar pattern to that of weight losses in this study. These simultaneous changes in appearance and weight loss values corroborate the mentioned reports.

Decay incidence

Figure 7 shows the decay rate which differed significantly ($P<0.0001$) among the treatments during the storage at 0° C. In control berries, decay incidence commenced between the first and second weeks of storage, while ethanol treatment prohibited the infection up to third week. After four week storage, the percentage of decayed berries in control was as high as 23.6%, whereas the treatments markedly delayed the decay incidence with the rates of 5.7, 7.5 and 12.1% for ethanol, MAP plus ethanol, and MAP, respectively. As previously indicated by Karabulut et al. (2004) and Gabler et al. (2005), the exposure of berries to ethanol solution remarkably inhibit the development of decay-causing microorganisms. Similar inhibitive effect was also stated for low level of oxygen by Philips (1996).

Sensory quality

The sensory quality of overall grapes decreased gradually along with the prolonged storage time (Figure 8). The magnitude of this reduction became evident in the 2nd week, although there was no visible change in overall quality of berry appearance up to the 3rd week of storage. This is most likely because visual decay commences after enzymatic reactions (such as polyphenol oxidase) responsible for deterioration take place inside the cell (Konig et al., 2009). Throughout the storage period, all the berries treated with MAP were well accepted by panellists. At the end of storage significant ($P<0.0001$) differences were observed in treatments. According to the mean of panellist scores, the berries of control group were ranked below the acceptable threshold level of the value 3. The explanation for such low level could be related to the higher weight loss determined in control. This case is well conformed to the results of Xu et al. (2007) who evaluated the quality changes of Redglobe grapes after various treatments by sensory analysis.

Conclusion

Overall results indicate that MAP in combination with ethanol dip to extent storage period of table grapes seems to be the best method, since ethanol restricts the development of postharvest microorgan-

isms while MAP slows down the respiration of commodity. Such combined effect would enhance the storage period of grapes by efficiently delaying reduction of fresh weight, SSC, pH, berry decay. In the combined use, ethanol is expected to sanitize the berry surface while MAP retards tissue senescence by restricting respiration rate of the berries.

References

Ahvenainen, R., 1996. New approaches in improving the shelf life of minimally processed fruit and vegetables. *Trends in Food Science and Technology*, **7:** 179187.

Anonymous, 2007. FAOSTAT-Agriculture (www.fao.org).

Athanasopoulos, P. and A. Thanos, 1998. Quality characteristics of Sultanina table grapes stored in a pilot plant scale. *Fruits*, **53:** 199206.

Brummell, D., V. Dal-Cin, C. H. Crisosto and J. M. Labavitch, 2004. Cell wall metabolism during maturation, ripening and senescence of peach fruit. *Journal of Experimental Botany*, **55:** 20292039.

Cappellini, R. A., M. J. Ceponis and G. W. Lightner, 1986. Disorders in table grape shipments to the New York market, 1972 1984. *Plant Disease*, **70:** 1075-1079.

Crisosto, C. H., D. Garner and G. M. Crisosto, 2002. High carbon dioxide atmospheres affect stored 'Thompson seedless' table grapes. *Hort. Science*, **37:** 10741078.

Crisosto, C. H. and F. G. Mitchell, 2000. Postharvest Handling Systems: Small Fruits. I. Table Grapes. In; Postharvest Technology of Horticultural Crops, Third Edition, DANR Publication #3311.

Deytieux, C., L. Geny, D. Lapaillerie, S. Claverol, M. Bonneu and B. Doneche, 2007. Proteome analysis of grape skins during ripening. *Journal of Experimental Botany*, **58:** 1851-1862.

Ergun, M., O. Akkaya and N. Ergun, 2008. Suitability of some mid-season table grape cultivars and types for minimally processed produce. *Journal of International des Sciences de la Vigne Vin*, **42:** 99-106.

Eris, A., C. Turkben, M. H. Ozer and J. Henze, 1993. A research on CA-storage of grape cultivars 'Alphonse Lavalle' and 'Razaki'. In; Proc. 6th Int CA Res. Conf. NRAES-71, Ithaca, NY, Cornell Univ. pp. 705710.

Fallik, E., 2004. Pre-storage hot water treatments (immersion, rinsing and brushing). Review. *Postharvest Biology and Technology*, **32:** 125134.

Gabler, F. M., J. L. Smilanick, J. M. Ghosoph and D. A. Margosan, 2005. Impact of postharvest hot water or ethanol treatment of table grapes on gray mold incidence, quality, and ethanol content. *Plant Disease*, **89:** 309316

Guillen, F. P., J. Zapata, D. Martinez-Romero, S. Castillo, M. Serrano and D. Valero, 2007. Improvement of the overall quality of table grapes stored under modified atmosphere packaging in combination with natural antimicrobial compounds. *Journal of Food Science*, **72:** 185190

Kader, A. A., 2002. Postharvest Technology of Horticultural Crops. University of California, Agriculture and Natural Resources, Publication 3311, Third Edition, 535 pp.

Karabulut, O. A., F. M. Gabler, M. Mansour and J. L. Smilanick, 2004. Postharvest ethanol and hot water treatments of table grapes to control gray mold. *Postharvest Biology and Technology*, **34**: 169177

Ke, D., E. Yahia, B. Hess, L. Zhou and A. A. Kader, 1995. Regulation of fermentative metabolism in avocado fruit under oxygen and carbon dioxide stresses. *Journal of American Society for Horticultural Science*, **120:** 481490.

Konig, H., G. Unden and H. Frohlich, 2009. Biology of Microorganisms on Grapes, In Must and in Wine. Springer-Verlag, Berlin, Heidelberg, 522 pp.

Kou, L., Y. Lou, D. Wu and X. Liu, 2007. Effects of mild heat treatment on microbial growth and product quality of packaged fresh-cut table grapes. *Journal of Food Science*, **72:** 567-573

Lichter, A., Y. Zutkhy, L. Sonego, O. Dvir, T. Kaplunov, P. Sarig and R. Ben-Arie, 2002. Ethanol controls postharvest decay of table grapes.

Postharvest Biology and Technology, **24**: 301-308

Martinez-Romero, D., F. Guillen, S. Castillo, D. Valero and M. Serrano, 2003. Modified atmosphere packaging maintains quality of table grapes. *Journal of Food Science*, **68:** 18381843.

Philips, C. A., 1996. Review: Modified atmosphere packaging and its effects on the microbiological quality and safety of produce. *International Journal of Food Science and Technology*, **31:** 463-479.

Reitmeier, C. A. and G. R.Nonnecke, 1991. Objective sensory evaluation of fresh day-neutral strawberry fruit. *Hort. Science*, **26:** 843-845.

Sabir, A., F. K. Sabir, S. Tangolar and I. T. Agar, 2006. Comparison of the effects of SO_2 generators with different concentrations of ethanol application on cold storage of grape *cv*. Alphonse Lavallée. *Journal of Cukurova University Agriculture Faculty*, **21:** 4550

Sabir, A., F. K. Sabir, S. Tangolar and I. T.Agar, 2008. Effects of ethanol and sulphurdioxide applications on storage period and quality characteristics in some grape cultivars. 4. Symposium on Storage and Marketing of Horticultural Produces, 08-11 October 2008, Antalya, Turkey 441448.

Sabir, A., E. Kafkas and S. Tangolar, 2010. Distribution of major sugars, acids and total phenols in juice of five grapevine (*Vitis* spp.) cultivars at different stages of berry development. *Spanish Journal of Agricultural Research* (In press).

Sacher, J. A., 1973. Senescence and postharvest physiology. *Annual Review of Plant Physiology*, **24:** 197-224.

Sanchez-Ballesta, M. T., J. B. Jimenez, I. Romero, J. M. Orea, R. Maldonado, A. Gonzalez-Urena, M. I. Escribano and C. Merodio, 2006. Effect of high CO_2 pretreatment on quality, fungal decay and molecular regulation of stilbene phytoalexin biosynthesis in stored table grape. *Postharvest Biology and Technology*, **42:** 209216.

Sanchez-Ballesta, M. T., I. Romeroa, J. B. Jimenez, J. M. Orea, A. Gonzalez-Urena, M. I. Escribano and C. Merodio, 2007. Involvement of the phenylpropanoid pathway in the response of table grapes to low temperature and high CO_2 levels. *Postharvest Biology and Technology*, **46:** 2935.

Soliva-Fortuny, R. C. and O. Martin-Belloso, 2003. New advances in extending the shelf-life of fresh-cut fruits: a review. *Trends in Food Science and Technology*, **14:** 341353.

Soylemezoglu, G., 2001. Storage of Table Grapes. Ankara University, Faculty of Agriculture, Department of Horticulture, *Ankara University Press*, 72 p.

Takeda, F., M. S. Saunders and J. A. Saunders, 1983. Physical and chemical changes in 'Muscadine' grapes during postharvest storage. *American Journal of Enology and Viticulture*, **34:** 180185.

Uzun, H. I. and A. Bayir, 2008. Viticulture in Turkey. Bulletion UASVM, *Horticulture*, **65:** 334-336.

Valero, D., J. M. Valverde, D. Martinez-Romero, F. Guillen, S. Castillo and M. Serrano, 2006. The combination of modified atmosphere packaging with eugenol or thymol to maintain quality, safety and functional properties of table grapes. *Postharvest Biology and Technology*, **41:** 317327.

Wills, R., B. Mcglasson, D. Graham and D. Joyce, 1998. Postharvest; an Introduction to the Physiology and Handling of Fruit, Vegetable and Ornmentals. Cab International, UNSW Press, 4th edition, 262 pp.

Winkler, A. J., J. A. Cook, W. M. Kliewer and L. A. Lider, 1974. General Viticulture. *Univ. California Press*, Berkeley, USA, 710 pp.

Xu, W. T., K. L. Huang, F. Guo, W. Qu, J. J. Yang, Z. H. Liang and Y. B. Lou, 2007. Postharvest grapefruit seed extract and chitosan treatments of table grapes to control *Botrytis cinerea*. *Postharvest Biology and Technology*, **46:** 8694.

Received February, 26, 2010; accepted for printing September, 23, 2010.