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The Effects of Heat Application on the Quality of Golden Delicious and Starking Delicious Apple Varieties

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Abstract: The objective of this study is to determine the effects of heat applications on fruit quality during the storage. Golden Delicious and Starking Delicious apple varieties used in this research were obtained from the Vineyard Research Institute located in Tekirdag. Research was carried out with three replications in randomized block design with split plots. Apples were treated with heat for 4 days at 38°C and then stored in Institute's cold air chambers under the conditions of 0°C with 85-90% relative humidity. During the heat application high weight loss occurred in fruits. This application was found to be effective on the firmness of the fruits during storage. The mean application was responsible of ripening by increasing the respiration rate and the starch degradation rate in fruits.

Key words: Heat treatment, apple, golden delicious, starking delicious, flesh firmness, respiration rate, postharvest, quality, maturity

INTRODUCTION

Apple is the most common fruit grown in the temperate climate zone (Anonymous, 1999). Apple, which is one of the highly consumed fruits in Turkey parallel to the consumption rates in the world, is an important fruit for Turkey in terms of both for its food value and its economical yields. The production was reach up to 2,550,000 tones in Turkey (Anonymous, 2005). Even though the apple production, which has an economic value, has increased, this value couldn't have been evaluated properly because of the problems seen after harvest. The main reasons of these problems are the post-harvest process and improper storage conditions.

Since the chemical applications, which are commonly carried out to prevent the quality of fruit after harvest in the last years, are harmful on human health, the reactions for these substances are increasing. In post harvest applications, the usage of synthetic chemicals especially against for plant disease control has been decreased. Therefore, it was revealed that, the heat application is one of the most attractive cotemporary applications for not only to preventing the post harvest quality of the fruits, but also to control the pesticides, diseases and harmful effects on fruits (Artes, 1995). In a research, the effect of pre-storage heat applications on storage of apples was studied and its effect on the decreasing the rate of softening was found to be the most beneficial (Klein ve Lurie, 1990).

The mechanism of heat application on decrease of ripening and the effects on maintaining the firmness by acting on cell wall has not been explained yet. However, it has been considered that the probable mechanism would have occurred by demolishing of the synthesis of the pectin break down enzymes (Conway *et al*., 1994). The study by Kim (1994) showed that the application of heat treatment on grapes and together with their bunches at 48°C for 2-4 days by Kim (1994) was resulted that this application damaged the fruit, but on the other hand the application of the heat treatment at 38°C for 2-4 days did not harm fruits.

For this purpose, the heat application applied before storage of apples was found beneficial by affecting the quality of apples during storage. With this way, the softening of fruit was reduced. Therefore, the effects of heat application on Golden Delicious and Starking Delicious Apple varieties quality was investigated in this research.

MATERIALS AND METHODS

Study continued for two years. Golden Delicious and Starking Delicious apple varieties used as research materials that were obtained from the Vineyard Research Institute located in Tekirdag (Anonymous, 1998). This research was carried out as a randomised block design with split plots. Apples were grouped and placed into chambers at 38°C. Four days (96 h) later apples were taken

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out from chambers and put into the boxes and stored for 6 months at cold air chambers at Tekirdag Vineyard Research Institute under the conditions of 0°C. Effects on the measured criterias were used on PRO-GLM according to the Statistical Analysis Systems (SAS Ins., 1999). Duncan's LSD test was applied to separate the means of the treatments.

Quality parameter analysis has been done at initially and following every two months during the storage to determine the quality reduction. The losses on fruits were measured by weight loss and it was defined as the percentage of the initial mass. The flesh firmness of the fruit pulp was determined by penetrometer with a tip radius of 11.1 mm and expressed as kg unit. Respiration measurements were determined by titration according to the prolonged air circulation method (Guckert *et al*., 1977). Starch loss on apples during the storage period were determined using scale (1 to 10) as it was described by Özelkök *et al*. (1993). Total Soluble Solids content percentage of the fruits was determined by directly using manual refractometer and reducing sugar and total sugar content was determined according to Rose (1959). Titrable Acidity (TA) measurement was based on neutralisation by adding alkali solutions on to the fruit juice.

RESULTS AND DISCUSSION

Weight loss: Variance analysis results showed that effects of variety ($p<0.001$), treatments ($p<0.001$) and time ($p<0.001$) on weight losses were statistically significant for both years. Although the weight loss measurements of the research revealed that heat application showed the

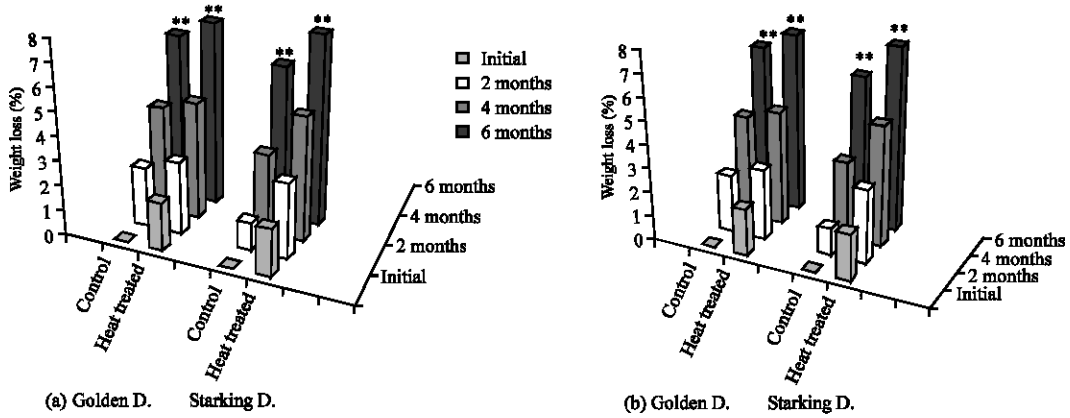

Fig. 1: Weight losses of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. * indicates significant differences at the levels of $p<0.05$* and $p<0.001$**

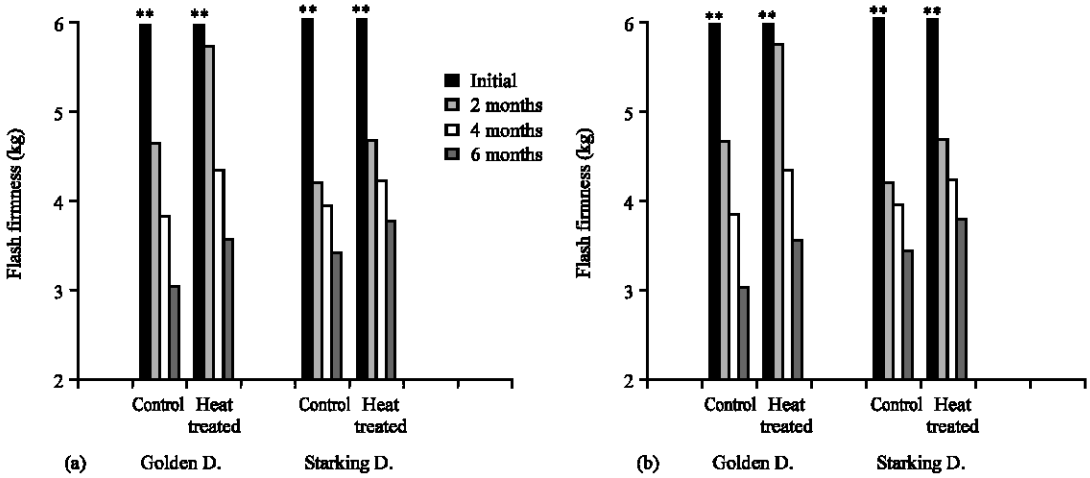

Fig. 2: Flesh firmness of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. * Indicates spastically significant at $p<0.05$, ** indicate spastically significant at $p<0.001$

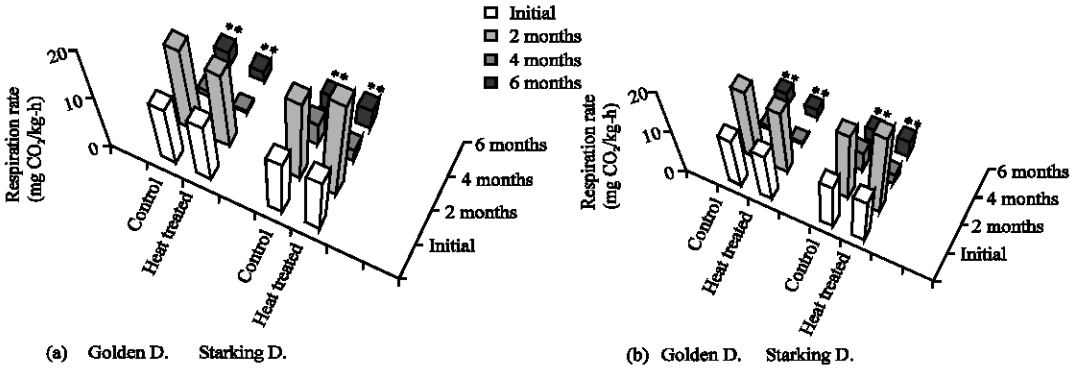

Fig. 3: Respiration rate of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. Star indicates significant differences at the levels of $p<0.05$* and $p<0.001$**

maximum mean weight lost value in the first year (Fig. 1a), the control apples had higher loss than the heat applied apples in the second year (Fig. 1b). During heat application fruits were lost 2% of their weights. It is thought that the maximum weight loss is caused by heat application. In the second year of the study, this application showed lower weight loss than the controls. During the two-year study, Golden Delicous variety apples had higher weight loss comparing to Starking Delicous variety. In a research by Ekinci and Çelik (1995), it was determined that not only the numbers of active lenticels of Golden Delicious type apples were found higher than other types, but also the weight loss was found to be higher in these apples. The weight loss results during cold storage were agreed with the data presented by Pekmezci (1975) who reported that monthly weight loss should not exceed 1%. However the second year weight loss values were found to be higher than Pekmezci's findings.

Flesh firmness: Variance analysis results showed that effects of variety ($p<0.04$), treatments ($p<0.001$) and time ($p<0.001$) on flesh firmness were statistically significant for both years. In the research heat application caused better flesh firmness in both years. Klein and Lurei (1990) defined that fruits showed better firmness and harder structure as a result of heat application. Investigation of the effects of fruit varieties on fruit flesh firmness showed no significant difference in the first year (Fig. 2a) of the study, however Starking apples showed significantly higher values in the second year (Fig. 2b). It is thought that climate and environmental factors could effect on the results. On the other hand, Ertan *et al.* (1991) were established that soil tillage methods, fertilization, ripeness, storage temperature and mainly the composition of the atmosphere in the fruit have effects on fruit firmness.

Respiration rate: Variance analysis results showed that effects of variety ($p<0.001$), treatments ($p<0.001$) and time ($p<0.001$) on respiration rate were statistically significant for both years. Interactions of variety × treatments × time was also significant. Respiration rate is one of the significant indicators in showing the metabolic activity of the tissue. In the research, no significant differences were found among treatments in the first year (Fig. 3a). The respiration rates of the control apples were greater than those of heat treated apples before the storage however heat applied apples showed maximum value two months after storage in the second year (Fig. 3b).

Starch ratio: Since the starch ratio which is one of the most important criteria for harvest maturation, is a pratically applicable method, it is producer's of importance. Variance analysis results showed that effects of variety on starch content was not significant in second year ($p<0.35$, Fig. 4b). Despite Golden Delicious apple's degradation was higher than Starking Delious in the first year (Fig. 4a). However, treatments ($p<0.001$) and time ($p<0.01$) on starch content were statistically significant for both years. The investigation of the heat applications on the starch degradation during the storage was showed that heat treatment increased the rate of starch degradation in both years.

Total Soluble Solids (TSS): Variance analysis results showed that effects of variety ($p<0.001$), treatments ($p<0.001$) and time ($p<0.001$) on total soluble solids were statistically significant for both years. Interactions of variety × treatments × time was also significant. The investigation of the effects of heat application on Total Soluble Solids (TSS) showed that mean TSS value of control apples were higher than those treated with heat in the first year (Fig. 5a). However TSS value of the apples

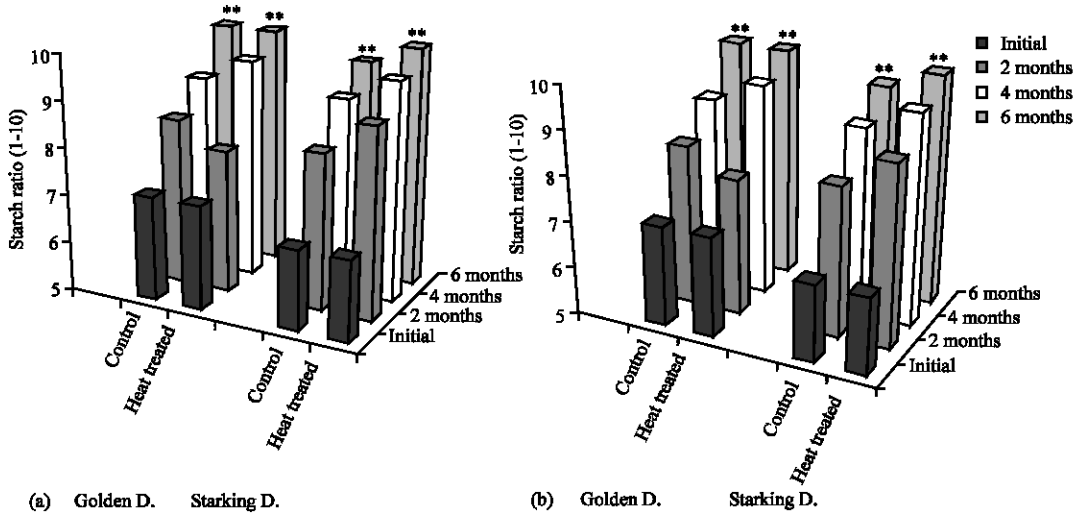

Fig. 4: Starch ratio (1-10) of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. Star indicates significant differences at the levels of $p<0.05$* and $p<0.001$**

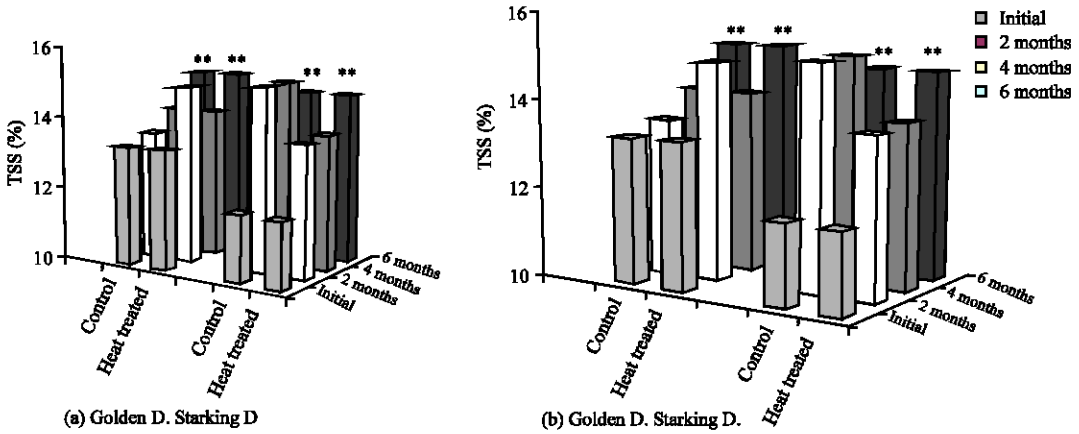

Fig. 5: Total soluble solids of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. Star indicates significant differences at the levels of $p<0.05$* and $p<0.001$**

treated with heat showed higher values in the second year than those of control (Fig. 5b). Klein and Lurie (1990) defined that heat applications had no effects on fruit TSS concentration. The investigation of the effects of apple varieties on TSS value showed that golden delicious apples had higher TSS content in the first year than TSS value of starking delicious apples. However starking delicious apples had higher TSS value than golden delicious apples in the second year. Malishevskaya (1973) announced that harvesting time is important for TSS content of the apples and this value is increasing proportionally according to the length of harvesting time. Therefore TSS contents of both apple variety was not the same at their harvest time. Because apples which had higher TSS content before storage had also higher TSS content after storage.

Invert sugar content: Variance analysis results showed that effects of variety ($p<0.001$), treatments ($p<0.001$) and time ($p<0.001$) on invert sugar content were statistically significant for both years. Interactions of variety × treatments × time was also significant. Heat-treated apples had higher invert sugar content comparing to the control apples in this study at first and second years (Fig. 6a and b). Since heat application increases maturity, starch degradation is also induced. Beruter and Ferusi (1997) explained this as an increase of the glucose content can reduce the starch level.

Total sugar content: In the study, total sugar content values were similar to invert sugar values. Heat treatment was resulted in high total invert sugar content. Variance analysis results showed that effects of variety ($p<0.001$),

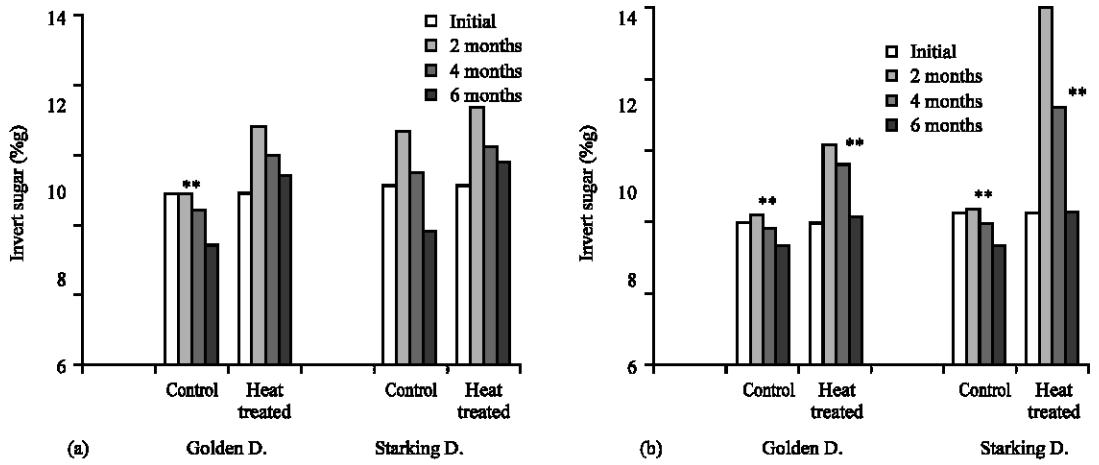

Fig. 6: Invert sugar content of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. Star indicates significant differences at the levels of $p<0.05$* and $p<0.001$**

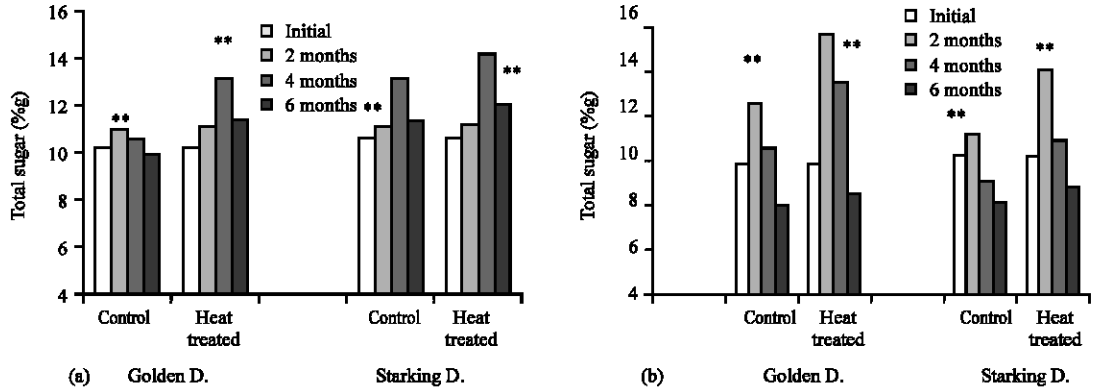

Fig. 7: Total sugar content of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. Star indicates significant differences at the levels of $p<0.05$* and $p<0.001$**

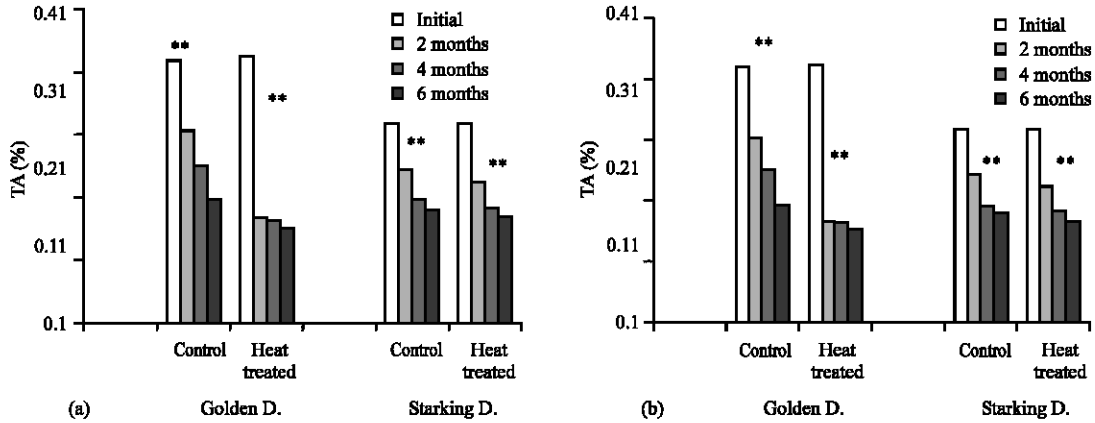

Fig. 8: Titratable acidity of golden delicious and starking delicious apple varieties in the first (a) and second year (b) of the experiment. Star indicates significant differences at the levels of $p<0.05$* and $p<0.001$**

treatments ($p<0.001$) and time ($p<0.001$) on total sugar content were statistically significant for both years. Interactions of variety × treatments × time was also significant. Heat treatment was resulted in high total sugar content. In the first year of the study Starking Apples (Fig. 7a), in the second year of the study Golden Delicious Apples showed higher values (Fig. 7b). This characteristic can be variable according to the variety in years, ecology, solid, pruning and etc. (Karaçali, 2004).

Titratable Acidity (TA): Variance analysis results showed that effects of variety ($p<0.001$), treatments ($p<0.001$) and time ($p<0.001$) on TA were statistically significant for both years. Interactions of variety × treatments × time was also significant. Since a sudden increase in temperature occurs, the heat application is resulted in an increased respiration rate and develops the maturation. The usage of organic acid in the respiration process generates a reduction in TA value. In a study by Liu (1978), it was determined that keeping some apple varieties under 40°C for 2-4 days reduced fruit acidity. However, it was announced that this reduction of the mass was depended on storage conditions. Kim (1994) reported that the acidity decreased during heat treatment the decrease. In our study, it was determined that heat treated apples' acidity values were extremely lower than the control ones at the end of the storage (Fig. 8a and b).

In conclusion, heat treatment was found effective in maintaining the hardness of the fruit pulp. However, it is considered that this application is not suitable for long term storage because of the speeding up the maturation process.

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