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EFFECTS OF HARVEST DATE AND PRE-STORAGE TREATMENTS (GA₃, TEMPERATURE), ON SUPERFICIAL SCALD ON "IMPERIAL DOUBLE-RED DELICIOUS" APPLES.

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Abstract

The effect of harvest date, GA₃ as pre-storage treatment and storage temperature (5° C for various periods) on superficial scald incidence was tested during the period 1993-94. The internal concentration of antioxidants, α-farnesene and conjugated trienes by using peel n-Hexane extracts was determined at harvest and at the end of the storage period.

The date of harvest had a significant effect on scald incidence ($R^2 = 0.990$). The later the apples were harvested the lower the scald % was noticed. Apples harvested after September 10 were much less susceptible to superficial scald (20%) than apples harvested earlier (65%). Scald % reached a maximum in February. During the experimental harvest period (September 3 - 28), slight changes in color as well as in FF and SS were noticed. However, a significant increase was noticed in the level of the internal antioxidants on September 7, that coincided with increased resistance of the apples to scald incidence. It is suggested that determination of the level of antioxidants at harvest can be used as an additional maturity indice in order to be sure that apple have developed well their antioxidant system.

Storage of apples at 5° C for periods up to 60 days and then at 0° C or at 0° - 0.5° C alternatively, for 20 days (60 days in total) significantly reduced scald %, most probably due to the increased level of antioxidants.

Application of GA₃ (500 - 2000 ppm), as a spray after harvest and then storage at 20°C for 4 days, before storage at 0° C, significantly reduced scald %. The role of GA₃ on scald incidence needs further investigation.

1. INTRODUCTION

Scald development has been associated with the cultivar, date of harvest, prevailing temperature before harvest, orchard locality and storage conditions (Ingle and D'Souza, 1989; Lau, 1993; Sfakiotakis *et al.*, 1993).

I.D. Red Delicious is a bud-sport of Starking Delicious, it keeps well under regular storage conditions for a period of 6 - 8 months, but it is very susceptible to scald (Manseka and Vasilakakis, 1993). Another disadvantage of this cultivar is the tendency to drop before harvest and especially under windy conditions. Growers,

being afraid of the pre-harvest drop but waiting for improved color to develop, are always confused about the perfect time to harvest.

To avoid scald, growers usually apply DPA before storage, as a spray or drench (Smock, 1957; Lau, 1990). However, chemical residues are always a matter of great concern for human safety. CA storage and especially ULO conditions proved to be very effective in preventing scald development of this cultivar (Manseka and Vasilakakis, 1993), however, ULO storage is not a common practice in Greece and it affects negatively the development of aroma in certain cultivars (Hatfield and Patterson, 1974; Lidster et al., 1983 b).

The damage on the skin of the fruit is caused by conjugated trienes produced after oxidation of α -farnesene (Huelin and Coggiola, 1970; Meigh, 1970). Also, it has been suggested that the content of natural antioxidants (e.g. α -tokopherol) plays an important role in preventing oxidation of α -farnesene and consequently scald development (Anet, 1974; Meir and Bramlage, 1988). Vasilakakis and Manseka (1993), when working with I.D.R. Delicious, found that late harvested apples, resistant to scald, had increased levels of antioxidants. The same authors working with "G. Smith" found that GA_3 or temperature, as pre-storage treatments, had a positive effect on reduction of scald %.

The present study was undertaken in order to find out the best time for harvesting I.D.R. Delicious by trying various maturity indices and also, to further elucidate the phenomenon of scald development and to find out about the effectiveness of other control measures (GA_3 , temperature), besides DPA or Ethoxyquin.

2. MATERIALS AND METHODS

Maturity indices - storage performance

Apples were harvested at 4-day intervals approximately, starting September 3, for a period of one month and on a sample of 30 apples. The following indices were determined: flesh firmness (F.F.), soluble solids (S.S.) and colour (on both sides red and green).

On every harvest date 160 apples were stored at 0° C for determining storage performance and to be further used for n-Hexane extractions.

Chemical treatments - storage conditions

Apples were stored directly at 0° C or at 5° C, for various durations 5, 10, 20 or 60 days, and then at 0° C. The effect of storage at 5° C, as intermittent storage period of 20 days, on scald development was also tested.

Determination of conjugated trienes, α -farnesene and antioxidants

Apples harvested on September 3, 7, 10, 16, 21 and 28 were stored at 0° C. Upon harvest, as well as once a month, samples of 10 apples were taken out of storage and used for determining conjugated trienes, α -farnesene and antioxidants by

applying UV absorption on n-Hexane extracts. The extraction procedure applied was a modification of that of Meir and Bramlage (1988). Ten grams of fresh peel (1 g/fruit) were extracted in 25 ml n-hexane for 3 min. Antioxidants, α -farnesene and conjugated trienes were expressed as OD-values of 0.4 grams peel in 20 ml.

Storage performance and scald

Apples were stored for 210 days. After 7 days at 20° C, scald % and scald score (0-60) were determined, as well as F.F. and S.S. All data were subject to statistical analysis.

3. RESULTS AND DISCUSSION

Maturity indices

From September 3 to September 28, flesh firmness almost remained the same (6.5 kg), soluble solids content increased by 1% and in color only minor changes (of a -Hunter values) were noticed on both green and red sides of the fruit (Fig. 1). However, a significant increase in the concentration of the antioxidants (OD-200 nm) was noticed on September 7 (Fig. 2A). This finding suggests that internal concentration of antioxidants could be used as a maturity indice for this cultivar and as it has been suggested by Watkins *et al* (1982), for other cultivars as well.

Scald in relation to harvest date

Apples harvested on September 3 (early) showed the highest scald % (65%) and thereafter a linear decline ($R^2 = 0.990$) was noticed up to September 10, and then it remained constant (Fig. 2B and C). Very mature apple were less susceptible than immature but they were not immune to scald (Knee and Hatfield, 1981; Meir and Bramlage, 1988). Scald % was increasing along with prolonged storage up to February 21.

Apples harvested between September 10 and 21 had developed satisfactory color, kept very well under regular storage at 0° C for a period of 210 days, they were rich in antioxidants and therefore less susceptible to scald. The present results suggest that, if the area is not damaged by winds, growers can postpone the harvest of their apples until they achieve satisfactory coloration and a high level of antioxidants.

Temperature

Storage at 5° C for 60 days, before storage at 0° C, reduced significantly scald by 30% (Fig. 3A). However, the most profound effect on scald reduction (40%) was achieved by alternation of storage temperature (5 - 0° C) for periods of 20 days, 60 days in total. Storage at 20° C for 4 days, before storage at 0° C, reduced scald by 15% (Fig. 3B, 0 ppm GA_3).

GA_3 and scald

Application of GA_3 (3000 ppm) reduced scald by 12%. However, combination of GA_3 (2000 ppm) and storage at 20° C for 4 days resulted in 25% scald reduction, meaning that there was an additive effect.

***n*-Hexane extracts - UV absorption - 200, 270 nm
OD-values in relation to duration of storage, temperature and GA3**

Apples at harvest did not contain any trienes (OD-270) or negligible amounts. During storage, a steady increase in concentration of trienes was noticed reaching a maximum in March. Apples harvested between September 7 and 21 contained similar levels of trienes (data not shown). There was no correlation between content of trienes and scald susceptibility in contrast to findings of other investigators (Huelin and Coggiola, 1970; Meigh, 1970).

Late harvested apples contained higher concentration of natural antioxidants at harvest as well as after 210 days in storage than early harvested ones. In addition to that, apples stored at 5° C before storage at 0° C were much less susceptible to scald and simultaneously they contained higher levels of antioxidants (Table 1). During 1993-94, scald % noticed was much lower than it was during the 1992-93 period on apples coming from the same orchard. The most obvious explanation of this phenomenon could be the observed cool nights in early September, resulting in better coloration as well as in higher levels of internal antioxidants.

4. CONCLUSIONS

OD-200nm values of *n*-hexane extracts at harvest can be used as an additional maturity indice.

Low temperature (5° C) as pre-storage treatment results in increased levels of antioxidants and reduced susceptibility to scald injury.

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Table 1. Levels of antioxidants and conjugated trienes in extracts of I.D. red Delicious apples in relation to storage temperature and GA pretreatment

Treatment	OD-200 nm	232 nm	268 nm
0° C	1.250	0.180	0.230
5° C - 10 days - 0° C	1.544	0.268	0.315
5° C - 60 days - 0° C	1.680	0.315	0.282
5° C continuously	1.828	0.265	0.172
0° C - 5 - 0 - 5 - 0° C	1.605	0.285	0.350
5° C - 0 - 5 - 0° C	1.660	0.266	0.265
GA 500 - 4d / 20° C - 0° C	1.370	0.130	0.190
GA 1000	1.404	0.145	0.205
GA 2000	1.410	0.172	0.200
GA 4000	1.410	0.170	0.200

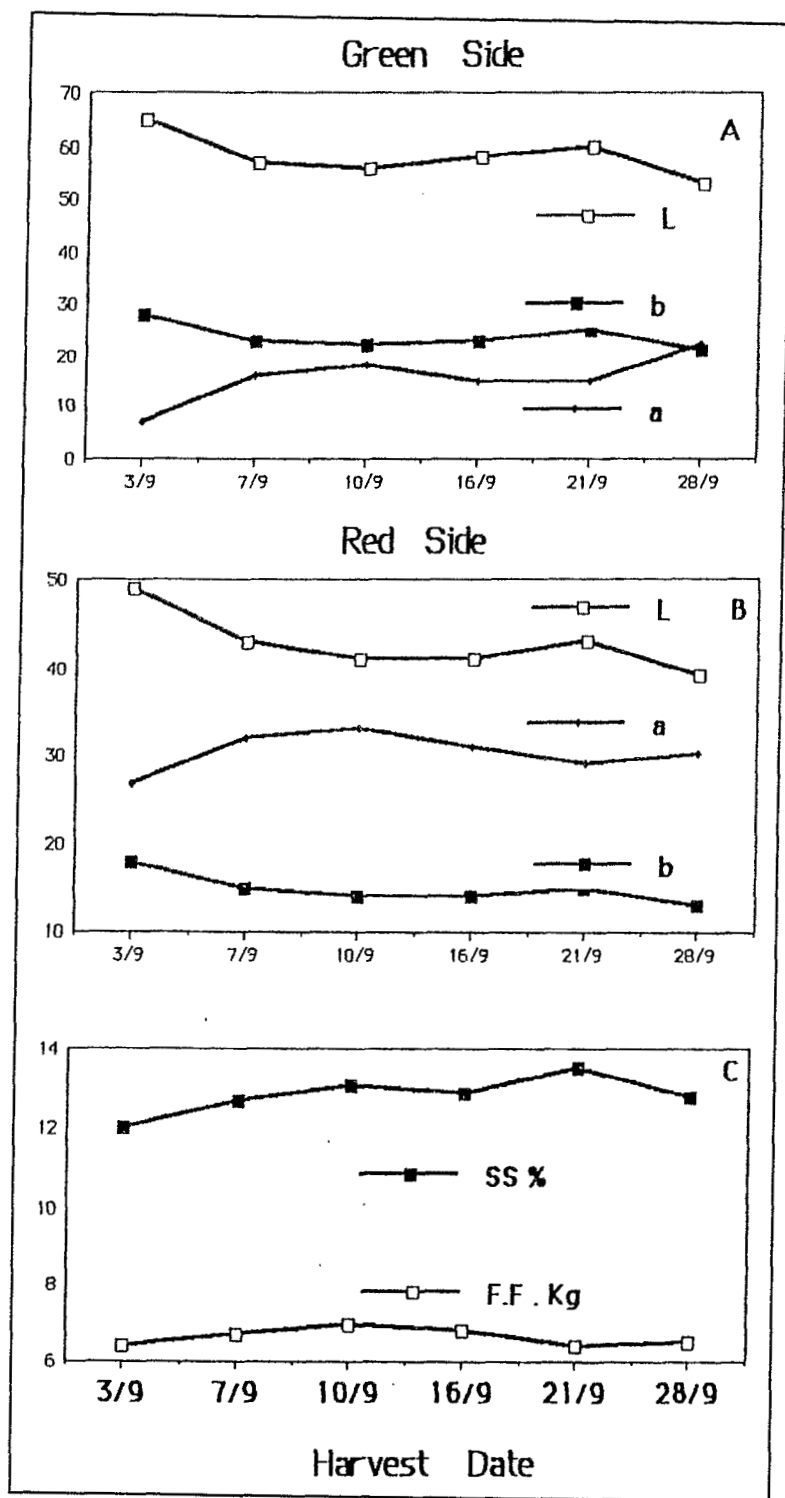


Fig. 1. Maturity indices of I.D.R. Delicious apples harvested at 5 day intervals, approximately.

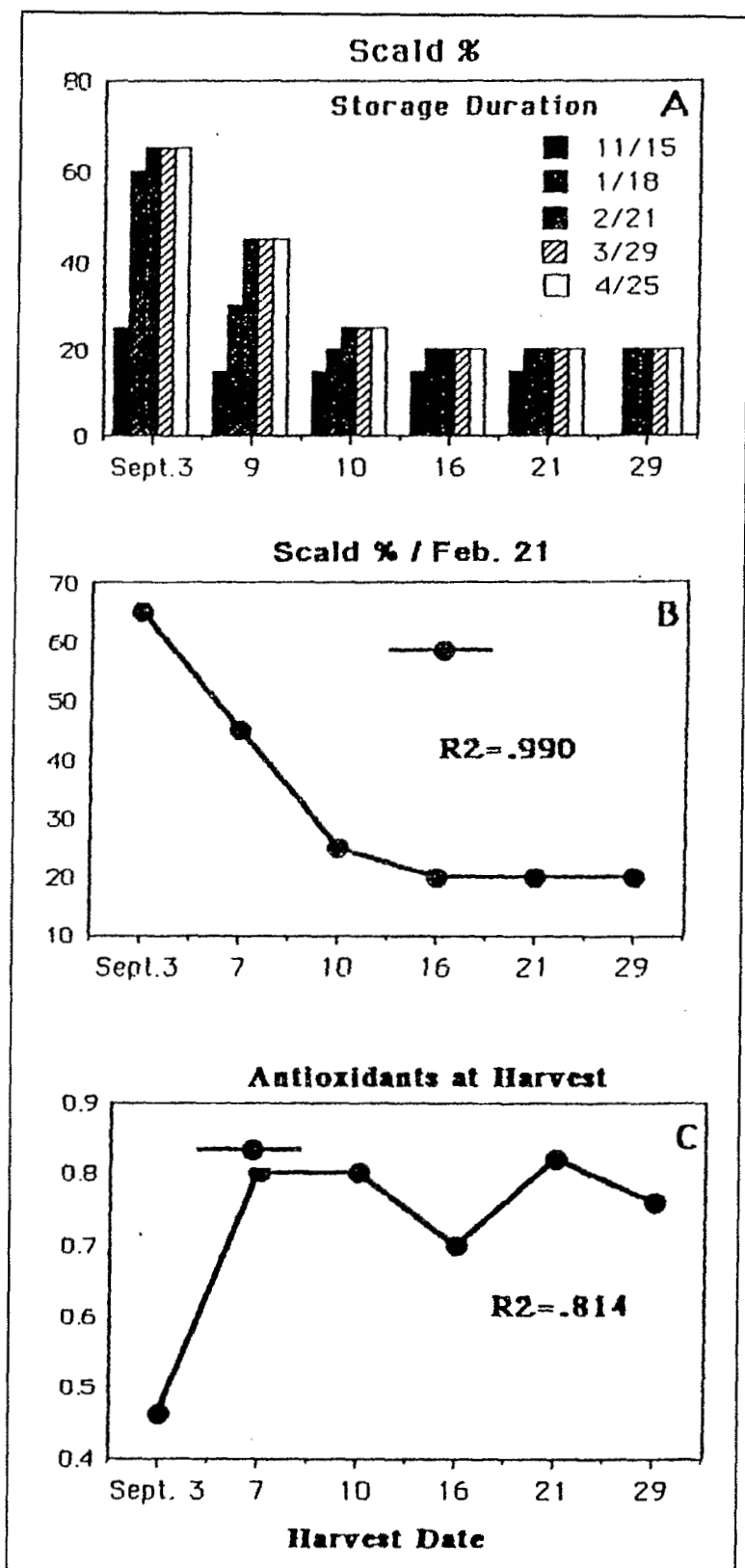


Fig. 2a. Scald % in relation to harvest date and storage duration
2b. Scald % on February 2 in relation to harvest date
2c. Levels of antioxidants in apples harvested at various maturity stages.

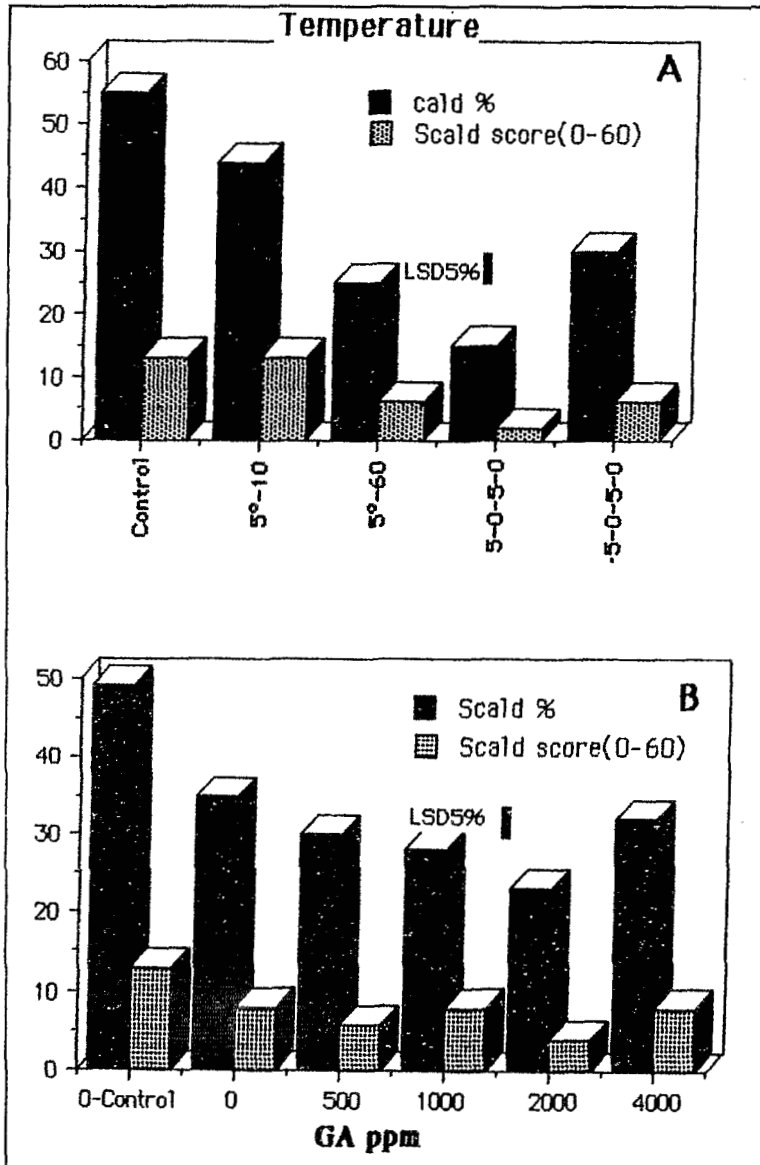


Fig. 3a. Effect of storage temperature at 5o C for various durations (10 - 60 days) or alternatively at 5 - 0o C for periods of 20 days (60 in total) on scald development of I.D.R. Delicious apples.

Fig. 3b. Effect of GA3 on scald development. Apples stored at 20o C for 4 days before storage at 0o C.