Influence of Thinning Method on Postharvest Quality of 'Golden Delicious Cl. B' Apple (*Malus domestica* Borkh.)

Tomislav JEMRIĆ
Nikola PAVIČIĆ
Martina SKENDROVIĆ

SUMMARY

The effect of hand vs. chemical fruit thinning with 1-naphthaleneacetamide (NAD) (40 ppm) and 1-naphthyl (N-) methylcarbamate (carbaryl) (1000 ppm) on apple fruit quality after 17 weeks in cold storage at 1 °C has been studied. Fruits from hand-thinned trees had lower weight loss (WL), firmness (F) and titratable acidity (TA), but soluble solids concentration (SSC) and SSC/TA were higher ($P \leq 0.001$). In chemically thinned fruits there was correlation between WL and SSC, WL and TA, SSC and TA, number of seeds per fruit and Hue angle. In hand-thinned fruit SSC/TA was correlated with Hue and WL. In both thinning methods SSC and WL were negatively correlated with Hue angle and positive correlation existed between WL and fruit weight. Further research should be made to find optimal thinning strategies that will have both good thinning effect and positive effect on fruit quality after storage.

KEY WORDS

Malus domestica Borkh., thinning, carbaryl, 1-naphthaleneacetamide, fruit quality, storage

University of Zagreb, Faculty of Agriculture, Department of Pomology
Svetošimunska 25, HR-10000 Zagreb, Croatia
E-mail: tjemric@agr.hr

Received: November 11, 2004

INTRODUCTION

The fruit thinning is regularly applied in apple in order to achieve regular yield and uniform quality. Chemical thinners reduce biennial bearing effect, the need for expensive manual thinning and improve the quality of the remaining fruits (Vercamen, 1997). The later is not always true, since contrary to positive effects such as increase in fruit weight (Pavičić and Paulić, 1989; Bound et al., 1993) and reduction in biennial bearing (Link, 1998; Vercamen, 1997.), the chemical thinning of fruit may sometimes cause adverse effects such as reduced yield (Byers and Carbaugh, 1991; Elfving and Cline, 1993a; Link, 1998; Marini, 1996; McArtney et al., 1995), reduced fruit growth (Jones et al., 1983.), fruit russeting (Pavičić and Paulić, 1989; Byers and Carbaugh, 1991; Bound et al., 1993.), fruit deformation (Rogers and Williams, 1977), poor fruit colour (Byers and Carbaugh, 1991; Link, 1991.), and lower calcium concentration in fruit (Elfving and Cline, 1993b.).

Most of the literature is focused on the effect of thinners on yield or other production aspects, while the fruit quality becomes a secondary issue. Link (2000) have reviewed the German experience with chemical thinning accumulated over three decades and concluded that there are two groups of quality components. First group includes size, colour, skin performance, firmness, sugar and acid content. The second group includes calcium and potassium levels which are important for storability and occurrence of physiological disorders. Thinning intensity differently affects these two groups, therefore it is important to select an optimal thinning strategy according to growing and local market conditions. The data reported in literature on the effect of chemical thinners on fruit quality differ. Hess et al. (1996) reported lower firmness and sugar content in chemically thinned apples, but there are also opposite results (El Salhy, 1996; Bound et al., 1998; Looney, 2000.). In some cases fruit quality did not appear to be affected by the treatments (Pfammatter and Dessimoz, 1999; Almanza et al., 2000.). Guzewski (1993) reports higher concentrations of fruit Ca, after thinning with NAA and carbaryl. However, Elfving and Cline (1993b) found the opposite effect using cytokinin and etephon. Therefore, thinners may differ in their effect on storability of apple fruits. NAA and GA can cause storage loss (Lafer, 2003) and it is important to find thinners with no such adverse effect on postharvest quality. 'Golden Delicious' apple often asks for additional hand thinning after aplication of chemical thinners (Schumacher et al., 1989) or for combining of NAD with carbaryl (Vercamen, 1997.) to achieve optimal results. Therefore the aim of this study was to determine the effect of hand and chemical thinning (NAD + carbaryl) on postharvest quality of 'Golden delicious clone B' apple. We showed that thinning method affects postharvest quality of apple and further research should be done to find underlying processes that cause such changes.

MATERIALS AND METHODS

Orchard

The thinning experiment was conducted in 2002, at the 'Golden delicious clone B' orchard near Daruvar (45§36' N and 17§14' E). The trees were grafted on M9 rootstock and planted at 0.7 m within a row and 3 m between rows. Training form is slender spindle and trees were 4 years old. Space between rows is grassed and all cultural practices are applied regularly.

Thinning experiments

Two thinning methods were tested. The first treatment was hand thinning to achieve one fruit per cluster when fruit diameter (FD) was between 12-16 mm, and the second treatment included chemical thinning with NAD (40 ppm at 8-12 mm FD) and carbaryl (1000 ppm at 12-16 mm FD). Spraying volume was 1200 L per ha.

Measurements and chemical analysis

Harvest date has been determined according to the standard method (Streif, 1995) and fruits were harvested on September 13, 2002.

The fruits were transported to the laboratory and visually inspected for damage and other defects. Then, four boxes of fruits (about 15 kg per box) per thinning treatment were formed. Each box represented one replication and 10 fruit per box were weighed and marked for determination of weight loss (WL) before putting in RA cold storage (90 % RH, 1§ C) for 17 weeks. After storage, fruits were left for additional week on room temperature to simulate retail market conditions. Then, marked fruit were weighed again and quality analysis was performed on all 40 fruits from each thinning method.

Colour was measured according to CIE Lab system on colorimeter (Colortec PCM, USA). The colorimeter calibration was done with black and white plates supplied with the instrument and the fruit colour was represented with Hue angle (H§) (McGuire, 1992).

Firmness was measured using Effegi FT 327 penetrometer with 11 mm probe as an average value from four measurements made at opposite fruit sides at equatorial fruit zone.

The juice from each fruit was extracted with electric jucier and was used for determination of soluble solids content (SSC) with refractometer (Carl Zeiss, Germany), and titratable acids (TA) by titration with

0.1 N NaOH and expressed in percent of malic acid per 100 ml of juice (Mitcham et al., 1996).

Data analysis

Data analysis was conducted with SAS software, version 6.12 (SAS Institute, Cary, NC, USA) using t-test and correlation analysis.

RESULTS

Fruits from the hand-thinned trees had lower weight loss, firmness, and TA. However, SSC and SSC/TA ratio were higher (P≤0.001) (Table 1). Colour was unaffected by thinning treatments. A positive correlation existed between weight loss and SSC in chemically thinned fruits (Table 2). In this treatment, WL was also positively correlated with TA. In hand-thinned fruits, weight loss was positively correlated with SSC/TA. In both thinning treatment, weight loss was negatively correlated with Hş. Fruit colour was negatively correlated with SSC and positive correlation existed between WL and fruit weight in both thinning methods. Number of seeds per fruit was negatively correlated with Hş and SSC was positively correlated with TA in chemically-thinned fruits. Fruit colour and SSC/TA were negatively correlated in hand-thinned fruits.

Table 2. Correlation coefficients between fruit characteristics of hand and chemically thinned fruits of 'Golden Delicious cl. B' apple (n=40)

Correlation	Thinning method	
	Hand	Chemical
Weight loss : SSC	n.s.	0.404*
Weight loss : TA	n.s.	0.321*
Weight loss : SSC/TA	0.323*	n.s.
Weight loss : Hue	– 0.709***	– 0.547***
Weight loss : Fruit weight	0.618***	0.495**
SSC : TA	n.s.	0.491**
SSC : Hue	–0.325*	–0.442**
SSC/TA : Hue	–0.374*	n.s.
No. of Seeds : Hue	n.s.	0.328*

Note: n.s., *, **, *** – nonsignificant or significant at P≤0.05, 0.01 and 0.001, respectively

DISCUSSION

Chemical thinning increased WL after storage, which is negative characteristic of this treatment (Table 1). This is also a result of increased fruit weight at harvest (Jemrić et al., 2003) since positive correlation existed between these two parameters for both thinning treatments (Table 2).

Increased firmness (Table 1) in chemically thinned fruits is positive characteristic of chemical thinners. At harvest, fruit firmness was higher in hand-thinned trees (Jemrić et al., 2003) which is contrary to the results of this study. Johnson (1994.) increased fruit firmness after storage by early hand thinning, but this effect was lost when fruits were stored in RA. He contributed this effect to the increase of SSC and related it to yield differences. Cited results are contrary the results of this study. Thinning method did not affect yield and productivity (Jemrić et al., 2003.) and no correlation existed between SSC and firmness after storage (data not shown). Guzewski (1993) found higher fruit Ca in 'Lobo' fruits after treatment with NAA and carbaryl. Pavičić et al. (2004) found that water soluble fraction of this element is responsible for incidence of storage disorder 'bitter pit'. They hypothesised that this fraction plays significant physiological role by changing enzymatic activity inside fruits. Therefore it is possible that the increased fruit firmness in chemically thinned fruits after storage is a result of changed activity of fruit softening enzymes. Higher weight loss in chemically thinned fruits (Table 1) might also contribute to the increased firmness, but this effect is only partial since no correlation existed between these two parameters.

It would be expected that increased weight loss in chemically thinned fruits would lead to the increase of SSC due to disappearance of water from the fruits and concentration of soluble solids. However, the opposite was true (Table 1). WL positively correlated with SSC in chemically thinned fruits (Table 2) but this correlation was not present in hand-thinned fruits. Therefore, lower SSC in chemically thinned fruits could be result of thinners. Lower fruit weight

Table 1. Effect of thinning method on postharvest fruit quality of 'Golden Delicious cl. B' apple (means are presented with SE based on 40 fruits)

Thinning method	Weight loss (%)	Firmness (kg/cm^2)	SSC (% Brix)	TA (% as malic)	SSC/TA	Colour (Hue °)
Hand	6.54±0.04	4.30±0.04	12.85±0.12	0.18±0.01	74.00±2.29	97.26±0.32
Chemical	6.74±0.05	5.00±0.07	11.50±0.21	0.24±0.01	49.74±1.27	97.84±0.45
t–test	***	***	***	***	***	n.s.

Note: n.s., *** – nonsignificant or significant at P≤ 0.001 according to t–test

in hand-thinned fruits (Jemrić et al., 2003.) is not contributing factor since no correlation existed between these two parameters for both thinning treatments.

TA was lower in hand-thinned fruits (Table 1), although no difference existed at harvest (Jemrić et al., 2003). This might be a result of concentration of acids due to higher weight loss in chemically thinned fruits (Table 1). A slight positive correlation existed between these two parameters in chemically thinned fruits, but not in hand-thinned fruits (Table 2). In chemically thinned fruits, positive correlation existed between SSC and TA which leads to conclusion that fruit metabolism was different depending on fruit thinning method. A slight positive correlation existed between SSC/TA ratio and WL, and negative with Hue in hand-thinned fruits (Table 2). Fruit colour was similar after storage (Table 1), but this was not the case at harvest (Jemrić et al., 2003). Change of colour is one of many biochemical changes occurring in fruit during ripening, therefore such results reflects the difference in dynamics of this processes during storage that was affected by thinning method.

Keulemans et al. (1996) describe the difference in fruit quality as result of the differences in seed number, but there are also opposite results (Ketchie et al., 1996). In this study the seed number was similar in both treatments (data not shown) and slight positive correlation existed between number of seeds per fruit and Hue in chemical thinning (Table 2). This is further evidence that observed differences in fruit quality are result of thinning methods.

Carbaryl, also used in our study, increased SSC and TA after harvest (Looney, 2000). However in this study, this was true only for TA. This was probably due to negative effect of NAD (Hess et al., 1996) or its interaction with carbaryl. The cultivar effect should not be overlooked since carbaryl effect is also cultivar dependent (Looney, 2000).

CONCLUSION

The described results show that the thinning methods significantly affect ripening of apple fruits. Therefore, this issue should receive much more scientific attention to find optimal thinning strategies that will have both good thinning effect and positive effect on fruit quality.

REFERENCES

Almanza F. J., Elos M., Lopez A., Valdez A. (2000). Efecto del aclareo quimico y manual en inflorescencias y frutos de manzano. Agronomia Mesoamericana 11:133-137

Bound S. A., Jones K. M., Graham B., Oakford M. J., Tichon M. (1993). Modelling the effects of timing and rates of application of benzyladenine as a secondary thinner of Fuji apple after etephon. J. Hort. Sci. 68:967-973

Bound S. A., Jones K. M., Oakford M. J. (1998). Post - bloom thinning with 6-benzyladenine. Acta Hortic 463: 493-500

Byers R. E., Carbaugh D. H. (1991). Effect of chemical thinning sprays on apple fruit set. HortTechnology 1: 41-48

El Salhy A. M. (1996): Effect of hand and chemical thinning on fruit retention and quality of Dorsett Golden trees. Assiut J Agric Sci 27: 119-132

Elfving D. C., Cline R. A. (1993a). Benzyladenyne and other chemicals for thinning Empire apple trees. J Am Soc Hort Sci 118: 593-598

Elfving D. C., Cline R.A. (1993b). Cytokinin and etephon affect crop load, shoot growth, and nutrient concentration of Empire apple trees. HortScience 28:1011-1014

Guzewski W. (1993). Mineral content and storage ability of apples from trees treated with chemical thinners and retardants. Acta Hortic 329: 254-256

Hess B., Stadler W., Bertschinger L., Krebs C., Schumacher R. (1996). Alternanz und fruchtqualität von Boskoop bei unterschiedlicher ausdünnung und bodenpflege. Obst und Weinbau 132: 282-274

Jemrić T., Pavičić N., Blaskovic D., Krapac M., Pavičić D. (2003): The effect of hand and chemical fruit thinning on ‚Golden Delicious cl. B' fruit quality. In: Current Studies of Biotechnology Vol III, Food (Z Kniewald, ed), Croatian Society of Biotechnology and Medicinska naklada, Zagreb, 193-198

Johnson D. S. (1992). Influence of flower and fruit thinning on the firmness of ‚Cox Orange Pippin' apples at harvest and after storage. J Hort Sci 67: 95-101

Johnson D. S. (1994). Influence of time of flower and fruit thinning on the firmness of ‚Coxs Orange Pippin' apples at harvest and after storage. J Hort Sci 69: 197-203

Jones K. M., Koen T. B., Meredith R. J. (1983). Thinning Golden Delicious apples using etephon sprays. J Hort Sci 58: 381-388

Ketchie D. O., Fairchild E. D., Drake F. R. (1996). Viability of different pear pollen and the effect on fruit set of Anjou pear (Pyrus communis L). Fruit Var J 50: 118-124

Keulemans J., Bruselle A., Eysenn R., Vercamen J., Van Daele G. (1996). Fruit weight in apple as influenced by seed number and pollinizer. Acta Hortic 423: 201-210

Lafer G. 2003. Auswirkungen der Applikation verschiedener Bioregulatoren auf die Ertragsleistung, Fruchtqualitat, Lagerfahigkeit und vegetative Entwicklung der Apfelsorten 'Elstar' und 'Gala'. Erwerbsobstbau 45: 69-96

Link H. (1991). Die aktuelle situation bei der fruchtausdünnung. Obst und Garten 110: 240-244

Link H. (1998) Effects of thinning in a long term trial with six apple cultivars on yield and fruit size. Acta Hortic 466: 59-64

Link H. (2000) Significance of flower and fruit thinning on fruit quality. Special issue: Abscission and thinning of young fruit - from molecular to applied aspects. Plant Growth Regul 31: 17-26

Looney N. E. (2000). Some effects of carbaryl on the growth and development of apple leaves: a possible mechanism for fruitlet thinning. Acta Hortic 527: 127-136

Marini R. P. (1996). Chemically thinning spur Delicious apples with carbaryl, NAA, and etephon at various stages of fruit development. HortTechnology 6: 241-246

McArtney S. J., Tustin D. S., Seymour S., Cashmore W., Looney. N. E. (1995). Benzyladenine and carbaryl effects on fruit thinning and the enhancement of return flowering of three apple cultivars. J Hort Sci 70: 287-296

McGuire R.G. (1992) Reporting of objective color measurements. HortScience 27: 1254-1255

Mitcham B., Cantwell M., Kader A. (1996) Methods for determining quality of fresh commodities. Perishables Handling Newsletter Issue No. 85: 1-6

Pavičić N., Paulić N. (1989). Effect of chemical thinning on the goldspur (Auvil spur) cultivar on the amount of yield, diameter, rustiness and the degree of ripeness of the fruit (in Croatian). Agronomski glasnik 55: 3-11

Pavičić N., Jemrić T., Kurtanjek Ž., Ćosić T., Pavlović I., Blašković D. (2004). Relationship between water-soluble Ca and other elements and the bitter pit occurrence in 'Idared' apples: a multivariate approach. Ann Appl Biol 145: 193-196

Pfammatter W., Dessimoz A. (1999). Eclaircissage chimique de pommiers Royal Gala et Braeburn. Revue Suisse Vitic Arboric Hortic 31: 299-302

Rogers B. L., Williams G. R. (1977). Chemical thinning of spur-type Delicious apple fruit. Virginia Fruit 65: 23-28.

Schumacher R., Stadler W., Weidmann G. (1989). Chemische fruchtausdünnung zur verbesserung der fruchtqualität bei der sorte Golden Delicious. Schweiz Z Obst-Weinbau 125: 503-513

Streif J. (1995) Optimum harvest date for different apple cultivars in the 'Bodensee' area. In: The postharvest treatment of fruit and vegetables. European Commission, Louxemburg: 15–20

Vercamen J. (1997). L'eclaircissage chimique du pommier: une technique don't on ne peut plus faire ion. Fruit Belge 65:51-54

acs70_02