

Harvest time effect on quality changes of apple cultivar 'Alva' during ripening and storage

**Nomeda Kviklienė, Darius Kviklys, Juozas Lanauskas,
Nobertas Uselis**

Lithuanian Institute of Horticulture, LT-54333 Babtai, Kaunas distr.

E-mail: n.kvikliene@lsdi.lt

In 2001, 2003 and 2005 at the Lithuanian Institute of Horticulture the following maturity parameters were evaluated to determine the optimum harvest date of apple cv. 'Alva' – fruit weight, blush, firmness, content of soluble solids and starch conversion. Apples for storage were harvested 5 times at weekly intervals before, during and after estimated optimum harvest date. The maturity index (F/RS) was calculated at each picking time. Quality changes, presence of storage disorders, mass losses were employed to estimate the optimum harvest date. It was found that fruit quality parameters both at harvest and after storage depended on the stage of ripeness at which the apples were picked. Apples, which were harvested earliest, were firmest both before and after storage, but lost a greater percentage of their firmness during storage. Later picked apples showed higher SSC value not only at harvest time, but at the end of storage too. Fruit picked 131 DAFB lose significantly less mass during storage in comparison with fruits picked too early or too late. Based on the changes in fruit quality parameters during ripening and storage, the optimal harvest time for 'Alva' is about 131 DAFB, when maturity index is 0.014.

Key words: *Malus × domestica*, fruit firmness, soluble solids content, starch index, storage.

Introduction. To ensure maximum storability, apples should be picked when mature, but not fully ripe. If apples are picked when they are too ripe, physiological processes are underway which complicate storage, even under optimal conditions (Ingle et al., 2000; Braun et al., 1995). Apples picked at right stage have the organoleptical qualities, which enable them to survive more than six months of storage.

To predict optimal harvest date (OHD) is possible by direct measurement of fruit quality parameters some weeks before the estimated harvest date and calculation of the maturity index. Streif maturity index is comprised of three maturity measurements (firmness, percentage of soluble solids concentration and starch conversion) (Streif, 1996). It has been successfully used to estimate the optimum of harvest date for various apple cultivars in different countries (Meresz et al., 1996, Skrzynski, 1996, DeLong et al., 1999). The index value is specific for each cultivar and it is not strongly dependent upon orchard management, soil and climatic conditions (Streif, 1996). Determination of the optimal harvest date is very important for growers to minimize losses during the storage and maximize post-storage quality of fruits.

Most fruit quality parameters are useful not only for gauging fruit maturity,

but for evaluating the eating quality of the apple as well (Hoehn et al., 2003). Fruit firmness is a measure of texture. SSC, acidity and sugar content are associated with taste. Volatile substances contribute to fruit aroma. Many factors affect fruit quality, including genetics, soil properties, and weather conditions.

The aim of this study was to investigate changes in fruit quality parameters during ripening and storage in order to determine the optimum harvest time for apples of the cultivar ‘Alva’.

Object, methods and conditions. In 2001, 2003 and 2005, changes in fruit quality parameters were studied in the apple cultivar ‘Alva’ grafted on MM.26 rootstock. The experiment was carried out with four replicates of ten trees per plot.

Every week during the ripening process, a batch of apples was gathered and put into long-term storage. Batches were picked 117, 123, 132, 139 and 146 days after full bloom (DAFB). Ten apples from each batch were immediately evaluated for weight, blush, firmness soluble solids content and starch index. Maturity index was calculated as F/RS, where F – firmness, R – soluble solids concentration, S – starch conversion.

At the 90, 150 and 180 day of storage apples from each batch were evaluated for firmness, soluble solids content, loss of mass and rot.

Firmness was measured with a penetrometer (FT-327) with 11 mm diameter probe. Soluble solids content was measured with a refractometer. The starch index was determined using a 0.1 N iodine and potassium iodine solution.

Data were statistically elaborated using ANOVA statistical program (Tarakanovas, Raudonius, 2003).

Results. During ripening period fruit weight increased up to 16 % and fruit blush to 38 % (Table 1).

Table 1. Effect of harvest time on fruit quality during ripening
1 lentelė. Skynimo laiko įtaka vaisių kokybei nokimo metu

Harvest time in days after full bloom (DAFB) Dienų skaičius nuo visiško žydėjimo iki skynimo	Fruit weight Vaisių masė (g)	Blush Nusispalvinimas (%)	Firmness Kietumas (kg/cm ²)	Soluble solids content Tirpios sausosios medžiagos (%)	Starch index Krakmolo indeksas	Maturity index Sunokimo indeksas
117	121	65	10.1	11.2	3.7	0.31
124	131	71	9.7	11.5	4.4	0.23
131	131	76	9.3	12.0	6.3	0.14
138	141	85	8.9	12.7	7.7	0.09
145	143	90	8.6	12.4	8.2	0.09
LSD ₀₅ / R ₀₅	5.6	3.2	0.19	0.17	0.42	0.022

During 5 weeks fruit firmness decreased on average from 10.1 to 8.6 kg/cm². A considerable change of fruit firmness appeared at each picking. Soluble solids content (SSC) linearly increased from 117 DAFB, and at 138 DAFB reached maximum after which it leveled off. The starch or Streif indexes decreased progressively over the investigation period. During five weeks period starch degradation changed from 3.7 to 8.2 points and maturity index changed from 0.31 to 0.09 points.

During storage, fruit firmness decreased from 36 to 44 % of its original value

(Table 2). The biggest softening rate was recorded after 90 days of storage. At this stage the earliest picked apples lost 32 % of their original firmness, while later picked apples lost only 17 %. After 150 and 180 days of storage softening processes of apples were slower.

Table 2. Effect of harvest time on fruit quality during storage
2 lentelė. Skyningo laiko įtaka vaisių kokybei laikymo metu

Harvest time in days after full bloom (DAFB) Dienų skaičius nuo visiško žydėjimo iki skyningo	Firmness Kietumas (kg/cm ²)			Soluble solids content Tirpios sausosios medžiagos (%)		
	after 90 days of storage	after 150 days of storage	after 180 days of storage	after 90 days of storage	after 150 days of storage	after 180 days of storage
	po 90 dienų	po 150 dienų	po 180 dienų	po 90 dienų	po 150 dienų	po 180 dienų
117	6.9	6.0	5.7	13.0	12.5	12.3
124	7.0	6.0	5.6	12.6	12.7	12.3
131	6.6	5.8	5.4	12.8	13.0	12.5
138	6.8	5.7	5.5	13.0	12.9	12.5
145	7.1	6.0	5.5	13.2	12.9	12.7
LSD ₀₅ / R ₀₅	0.17	0.11	0.13	0.19	0.20	0.14

Content of soluble solids showed tendency to increase during the storage. The maximum content was reached after 90 days of storage, later it slightly decreased. Fruits picked at the latest harvest date had the highest content of soluble solids during whole storage period.

Apple mass loss of cv. ‘Alva’ reached 8.0–9.9 % during 180 days of storage. The largest mass loss was estimated for earlier and later picked apples. Mass reductions were lowest of apples picked at 131 DAFB.

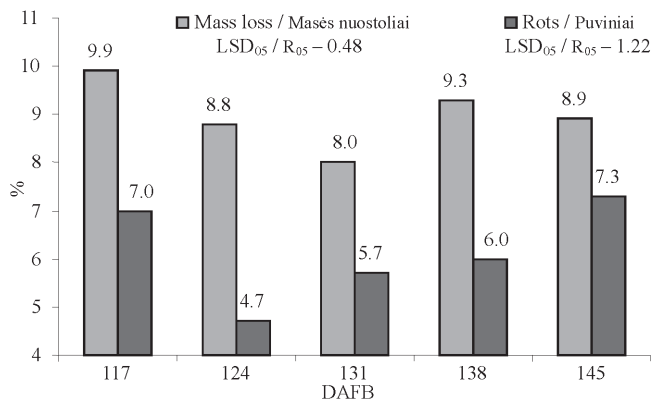


Fig. Harvest time effect on fruit loss during storage (%)
Pav. Skyningo laiko įtaka masės nuostoliams laikymo metu, %

Apple loss by rots and decay were not large. Up to 7.3 % of apples rotted during 180 days of storage period. Too early and too late picked fruits had bigger losses. Significantly less amount of rotten fruits was recorded when apples were picked at 124 and 131 DAFB.

Discussion. During investigation period all fruit quality parameters changed according to harvest date. Measurement of firmness, SSC, starch conversion indicated that apples from late harvest were most mature. Later harvested fruits were softer, had higher starch indices and SSC. The fruit characteristics at harvest affected fruit quality at the end of storage.

Measurements of firmness showed, that cv. 'Alva' belongs to the group of naturally firm fruits. Apples, which were harvested the earliest, were firmest both before and after storage, but lost a greater percentage of their firmness during storage. Apples harvested 117 DAFB had a firmness of 10.1 kg/cm² at harvest and 5.7 kg/cm² after storage, and lost 44 % of their initial firmness. Apples harvested 144 DAFB lost only 36 % of their initial firmness. This agrees well with an earlier study on fruit softening in other cultivars (Meresz et al., 1993, Kviklienė et al., 2006). The softening rate has also been reported to vary from cultivar to cultivar, depending on the presence and expression of genes, which regulate the activity of hydrolytic enzymes (Ingle et al., 2000; Konopacka, Plocharski, 2002; Johnston et al., 2001).

The concentration of soluble solids is a good indicator of sugar content and presumably of sweetness. Usually later picked apples show higher SSC value not only at harvest time, but at the end of storage too (YongSoo et al., 1998). Similar results were obtained in our trials too. However, in other cultivars, post-storage SSC was not significantly affected by harvest time (Kviklienė, 2004; Braun et al., 1995).

Loss of mass and decay during storage can greatly affect marketability. Mass loss during storage depends on fruit maturity at harvest time (Ferguson et al., 1999). Fruit picked at the optimal harvest time lose less mass during storage than fruits picked too early or too late (Elgar et al., 1999; DeLong et al., 1999; Dris, Niskanen, 1999). In our trials lower general fruit losses were at the optimal harvest time. Too early and too late picked fruits had bigger losses. Apples picked 138–145 DAFB were over-ripen and too metabolically active, whereas apples picked 117 DAFB had more injuries due to not fully developed skin.

Based on the changes in fruit quality parameters during ripening and storage, the optimal harvest time for 'Alva' is about 131 DAFB, when maturity index is 0.014.

Conclusions. 1. Fruits of cv. 'Alva' picked 131 DAFB have the best storability and postharvest quality.

2. Too late or too early picked fruits rotted by 23 % and 11 % more than fruits picked at the optimum harvest time.

3. At optimum harvest date the starch index of 'Alva' apples is 7.7, fruit firmness 9.3 kg/cm² and maturity index is 0.014.

*Gauta 2008 03 04
Parengta spausdinti 2008 03 18*

References

1. Braun H., Brosh B., Ecker P., Krumbock K. 1995. Changes in quality of apples before, during and after CA-cold storage. *Obstau Und Fruchteverwertung*, 45(5–6): 143–206.
2. DeLong J. M., Prange R. K., Harison P. A., Shofield R. A. and DeEll J. R. 1999. Using the Streif index as a final harvest window for controlled-atmosphere storage apples. *Hort. Science*, 34(7): 1 251—1 255.
3. Dris R., Niskanen R. 1999. Quality changes of ‘Lobo’ apples during cold storage. *Acta Hort.*, 485: 125–133.
4. Elgar H. J., Watkins C. B., Lalu N. 1999. Harvest date and crop load effects on a carbon dioxide-related storage injury of ‘Braeburn’ apple. *Hort. Science*, 34(2): 305–309.
5. Ferguson I., Volz R., Woolf A. 1999. Preharvest factors affecting physiological disorders of fruit. *Posthar. Biol. Technol.*, 15: 255–262.
6. Hoehn E., Gasser F., Guggenbuhl B., Kunsch U. 2003. Efficacy of instrumental measurements for determination of minimum requirements of firmness, soluble solids, and acidity of several apple varieties in comparison to consumer expectations. *Posthar. Biol. Technol.*, 27: 27–37.
7. Ingle M., D’Souza M. C., Townsend E. C. 2000. Fruit characteristics of York apples during development and after storage. *Hort. Science*, 35(1): 95–98.
8. Yong Soo H., Yong-Pil Ch., Yac Chang L. 1998. Influence of harvest date and postharvest treatments on fruit quality during storage and simulated marketing in ‘Fuji’ apples. *J. of Korean soc. For Hor. Sc.*, 39(5): 574–578.
9. Johnston D. S., Hewett E. W., Banks N. H., Harker F. R., Hertog M. L. A. T. M. 2001. Physical change in apple texture with fruit temperature: Effect of cultivar and time of storage. *Posthar. Biol. Technol.*, 16: 107–118.
10. Konopacka D., Plochanski W. J. 2002. Effect of picking maturity, storage technology and shelf-life on changes of apple firmness of ‘Elstar’, ‘Jonagold’ and ‘Gloster’ cultivars. *J. Fruit Ornam. Plant Res.*, 10: 11–22.
11. Kviklienė N. 2004. Influence of harvest date on physiological and biochemical processes in apple fruit. *Sodininkystė ir daržininkystė*, 23(2): 412–420.
12. Kviklienė N., Kviklys D., Viškelis P. 2006. Changes in fruit quality during ripening and storage in the apple cultivar ‘Auksis’. *J. Fruit Ornam. Plant Res.*, 14(2): 195–206.
13. Meresz P., Sass P., Lovasz T. 1996. Evaluation of harvest index of apples growing in Hungary. In: A. de Jager, D. Johanson, E. Hohn (eds.), *The Postharvest Treatment of Fruit and Vegetables. Determination and Prediction of Optimum Harvest Date of Apples and Pears. COST 94. European Commission. Luxembourg*, 53–60.
14. Skrzynski J. 1996. Optimum harvest date study of 4 apples cultivars in Southern Poland. In: A. de Jager, D. Johanson, E. Hohn (eds.), *The Postharvest Treatment of Fruit and Vegetables. Determination and Prediction of Optimum Harvest Date of Apples and Pears. COST 94. European Commission. Luxembourg*, 61–66.

15. Streif J. 1996. Optimum harvest date for different apples cultivars in the 'Bodensee' area. In: A. de Jager, D. Johanson, E. Hohn (eds.), The Postharvest Treatment of Fruit and Vegetables. Determination and Prediction of Optimum Harvest Date of Apples and Pears. COST 94. European Commission. Luxembourg, 15–20.
16. Tarakanovas P., Raudonius S. 2003. Agronominių tyrimų statistinė analizė, taikant kompiuterinę programą ANOVA, STAT, SPLIT-PLOT iš paketo IRRISTAT. Akademija, Kėdainių r.

SODININKYSTĖ IR DARŽININKYSTĖ. MOKSLO DARBAI. 2008. 27(1).

Skynimo laiko įtaka 'Alva' obuolių kokybei vaisiams nokstant ir juos laikant

N. Kviklienė, D. Kviklys, J. Lanauskas, N. Uselis

Santrauka

2001, 2003 ir 2005 m. Lietuvos sodininkystės ir daržininkystės institute tirta veislės 'Alva' obuolių kokybė vaisiams nokstant ir juos laikant. Vaisiai buvo skinti kas savaitę penkis kartus. Vaisiams nokstant buvo nustatyta: vidutinė vaisiaus masė, spalva, minkštimo kietumas, krakmolo susiskaidymas, tirpių sausųjų medžiagų kiekis. Kiekvieno skynimo metu apskaičiuotas sunokimo indeksas (kietumas/tirpios sausosios medžiagos × krakmolo susiskaidymas). Obuolius laikant nustatytas jų minkštimo kietumas, tirpių sausųjų medžiagų kiekis ir apskaičiuoti masės nuostoliai. Laikymo pabaigoje nustatytas optimalus skynimo laikas atsižvelgiant į tai, kurie vaisiai geriausiai išsilaikė. Nustatyta, kad vaisių kokybė skynimo ir laikymo metu priklausė nuo sunokimo laipsnio. Anksčiau nuskinti vaisiai buvo kietesni ir skynimo metu, ir laikymo pabaigoje, tačiau pektinų hidrolizės procesai juose vyko sparčiau. Vėliau nuskintuose obuoliuose buvo daugiau tirpių sausųjų medžiagų. Natūralius masės nuostolius ir nuostolius dėl puvinių taip pat lėmė skynimo laikas. Per anksti ir per vėlai skintų vaisių masės nuostoliai buvo didesni. Statistiškai mažiausi masės nuostoliai buvo variante, kur vaisiai nuskinti praėjus 131 dienai nuo visiško žydėjimo. Ilgai laikyti skirtus 'Alva' vaisius reikia skinti, kai jų sunokimo indeksas yra 0,014.

Reikšminiai žodžiai: *Malus × domestica*, krakmolo susiskaidymas, laikymas, minkštimo kietumas, tirpių sausosios medžiagos.