Effect of harvest maturity on quality and storage ability of apple cv. ‘Ligol’

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The effect of fruit maturity on apple cv. ‘Ligol’ storage ability and rot development was investigated at the Lithuanian Institute of Horticulture in 2003–2004. Fruits for storage were harvested 5 times at weekly intervals before, during and after predictable optimum harvest date. Fruit internal and external quality changes were measured during harvest period, and the presence of storage disorders and mass losses at the end of storage. During investigation period fruit quality parameters changed according to harvest date and were specific for each trial year. Later harvested fruits were softer. Content of soluble solids did not depend on harvest time. Fruit storage ability was closely connected to fruit maturity. After 180 days of storage apples picked one week before climacteric peak were of the best quality and with the smallest mass losses caused by decay and water loss.

Key words: Malus domestica, fruit firmness, rots, soluble solids content, storage, weight loss.

Introduction. A different picking date of apple fruits during the harvest season may have a significant impact on fruit quality (Vielma et al., 2008; Rizzolo et al., 2006; Kviklienė, 2001; Franelli, Casera, 1996; Meresz et al., 1996; Streif, 1996). To ensure the highest fruit quality at the end of long storage, apples must be harvested when mature but not when fully ripe. If harvested too early fruits are smaller, have reduced flavour and colour, and are more susceptible to scald, bitter rot and internal breakdown. Mass reduction by water loss is greater in earlier picked apples because waxy surface is not completely formed at this moment (Zerbini et al., 1999; Juan et al., 1999). Early picked fruits are smaller and their surface in a storage unit is larger. Because water transpiration depends on fruit surface area too, small fruits loss their weight faster. Another reason of more intensive evaporation is structure of fruit cuticle, which is not fully developed when fruits are harvested too early. At the same time the cuticle is the first barrier that pathogens have to challenge (Ihabi et al., 1998). Later picked apples often are over mature and all physiological processes are underway what complicate storage, even under optimal conditions (Ingle et al., 2000; Braun et al., 1995). Apples harvested too late are vulnerable to mechanical inures, sensitive to low temperature breakdown, watercore and more rot (Hribar et al., 1996). At optimal harvest time picked apples have the organoleptic qualities (Casals et al., 2006), which enable them to survive more than six months of storage.

The objective of this study was to investigate the effect of harvest time on fruit quality and storage ability of cv. ‘Ligol’ apples.
Object, methods and conditions. Investigations were carried out with apple cv. ‘Ligol’ on M.26 rootstock in 2003 and 2004. The measurements of fruit quality changes were performed 2–3 weeks before and after the predictable optimum harvest date. Apples for long storage were harvested 5 times at weekly intervals. The experiment was carried out with 4 replications and 5 trees per plot.

On each picking date 10 fruits from each replication were taken for laboratory measurements: respiration intensity (mg CO₂/kg h, measured with gas analyzer ‘Anagas 95’), fruit firmness (kg/cm², measured with penetrometer FT-327 with 11 mm diameter probe), soluble solids content (% , with refractometer).

On each picking date 100 fruits from each replication were taken in order to measure storability (firmness, soluble solids concentration, weight loss, storage disorders and rots). Fruits were stored for 180 days.

Variance analysis of main quality characters was done using ‘ANOVA’ statistical program.

Results. It was found that respiration pattern during the maturation period was typical for climacteric fruits and was similar during both years of investigation (Fig. 1). Early picked apples had reduced respiration. Respiration intensity increased until 4th harvest and reached climacteric maximum, thereafter strong decrease in respiration was recorded.

During ripening period fruit firmness decreased by 13 % in 2003 and by 22 % in 2004 (Table 1). In 2003 significant differences were recorded starting from the 3rd harvest. In 2004 fruits were firmer and did not differ significantly from 1st to 3rd harvest times. In both year of investigation the highest softening rate was observed at the last week.

At the end of the storage differences between fruit firmness were not so big. Significant differences were established comparing last two harvest dates with earlier
ones only. The difference in fruit firmness between first and last harvest date was 9 % in 2003, and only 5 % in 2004.

On average fruit firmness at harvest time gradually decreased according harvest time and in most cases differences between dates were significant. After the storage there were no differences between 1st and 3rd, and between 4th and 5th harvest dates. During storage, fruit firmness decreased on average from 21 to 37 % of its original value. The highest reduction of fruit firmness was recorded at 4th harvest.

Table 1. Effect of harvest time on fruit firmness (kg cm$^{-2}$)

<table>
<thead>
<tr>
<th>Harvest</th>
<th>2003</th>
<th>2004</th>
<th>Average</th>
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<td></td>
<td>at harvest</td>
<td>after storage laikymo pabaigoje</td>
<td>at harvest</td>
</tr>
<tr>
<td>1</td>
<td>7.7</td>
<td>5.8</td>
<td>8.8</td>
</tr>
<tr>
<td>2</td>
<td>7.6</td>
<td>5.7</td>
<td>8.5</td>
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<tr>
<td>3</td>
<td>7.3</td>
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<td>4</td>
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<tr>
<td>5</td>
<td>6.8</td>
<td>5.3</td>
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LSD$_{0.05}$ / R$_{0.05}$ = 0.21 / 0.17; 0.28 / 0.19; 0.15 / 0.14

The dynamic of soluble solid content (SSC) every year was different (Table 2). In 2003 SSC increased linearly to harvest time. The highest amount of SSC was observed in the last week of measurements, though significant difference was established only with 1st harvest date. In 2004 SSC reached maximum at 3rd harvest after which it leveled off.

In 2003 there were no significant differences in fruit SSC after the 180 days of cold storage. During the storage period decrement of SSC was recorded for most of harvest dates, while in 2004 opposite tendencies were defined. Almost at all harvest dates SSC showed a tendency to increase.

Table 2. Effect of harvest time on SSC (%)
Weight losses during storage were dissimilar every year (Fig. 2) and depended on harvest time. In 2003 the largest weight losses were estimated for earlier picked apples. Apples picked at 4th harvest lost by 27% less their mass in comparison with apples picked at earliest time. In 2004 the largest weight loss was estimated for earlier and later picked apples. Mass reduction was lowest of apples picked at 3rd harvest.

![Fig. 2. Effect of harvest time on fruit weight losses during storage](image)

Apple mass loss by rots and decay were not large in 2003 (Fig. 3). Up to 9.6% of apples rotted during 180 days of storage period. Too late picked fruits rotted more. Significantly less amount of rotten fruits was recorded when apples were picked at 2nd and 3rd harvest. Up to 33.9% of apples rotted in 2004 year. The extent of loss linearly depended on harvest time. At each picking the significant increase of rotten apples was recorded and the maximum of damaged fruits was estimated of latest picked apples. At this stage picked apples rotted by 4.8 times more, in comparison with apples picked at earliest harvest.

Cv. ‘Ligol’ apples were infected by Monilinia sp., Gloeosporium spp. and Penicillium spp. In both trial years apples were mostly infected by fungus of Gloeosporium genus.
Discussion. During investigation period fruit quality parameters changed according to harvest date and were specific for each trial year. Later harvested fruits were softer and had higher content of soluble solids. Fruit storage ability was closely connected to fruit maturity too. After 180 days of storage apples picked one week before climacteric peak were of the best quality and with the smallest mass losses caused by decay and water loss.

The softening rate of apple fruit 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., 2002). In our trials measurements of firmness showed that cv. ‘Ligol’ belongs to the group of naturally firm fruits. Softening rate during ripening and storage was low. In comparison with other investigated cultivars as ‘Auksis’, ‘Lobo’ and ‘Lodel’ fruits of cv. ‘Ligol’ tended to lose their firmness slower (Kvikliene, 2001; Kvikliene et al., 2006). In our trials the highest softening of fruits was observed when apples picked at climacteric peak, and the lowest – one week before. Apples harvested at optimal harvest time usually tend to loose their firmness during the storage much slower what agree with results of Castro et al. (2007), Kvikliene (2004), Hriber et al. (1996), and Meresh et al. (1993).

Usually, later picked apples show higher SSC value not only at harvest time, but at the end of storage too (YongSoo et al., 1998). In our study SSC varied during the years so it is difficult to draw a conclusion on the change pattern. Similar tendencies were obtained in different trials (Kvikliene et al., 2006; Wargo, Watkins, 2004; Echeverria et al., 2002; Braun et al., 1995).

The results of our investigations showed that mass reduction by water loss and decay was closely connected with fruit maturity. On average the lowest loss were observed of apples picked one week before climacteric peak. The bigger weight loss at early stage of maturation can be explained by not fully developed waxy surface.
and cuticle (Ihabi et al., 1998; Sass and Lakner, 1998). The higher incidence of rots in later picked apples can be explained by more intensive all physiological processes in overmature fruits. Similar results were recorded with other apple cultivars (Dris & Niskanen, 1999; Elgar et al., 1999; Ingle et al., 2000; Kviklienė, 2001).

Conclusions. 1. Harvest time has a significant effect on fruit internal quality and fruit physiological processes at harvest time and during the storage.

2. Fruit SSC depended more on growing season conditions neither on fruit maturity.

3. Incidence of decay and rots depended linearly on fruit maturity – more late harvest more fruit loss.

4. Cv. ‘Ligol’ apples harvested one week before climacteric maximum have the best storage ability.

References


**SODININKYSTĖ IR DARŽININKYSTĖ. MOKSLO DARAI. 2008. 27(2).**

**Skynimo laiko įtaka ‘Ligol’ obuolių kokybei vaisiams nokstant ir juos laikant**

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*Santrauka*


**Reikšminiai žodžiai:** *Malus × domestica*, kraikiomos susiskaidymas, laikymas, minkštimo kietumas, tiršios sausosios medžiagos, puviniai.