QUALITY OF ‘JONICA’ APPLE FRUIT AS INFLUENCED BY ROOTSTOCKS

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Abstract. The influence of five vegetative rootstocks (M.9, M.26, P 22, P 59 and P 60) on fruit quality was evaluated. Fruit size, flesh firmness, seed number, starch index (SI), soluble solids content (SSC), and titratable acidity (TA) were measured during two consecutive seasons. The analysis was performed at optimum harvest date time and after 6 months of storage, followed by simulated shelf life period at 20°C. There was no evident effect of rootstocks on fruit maturity at harvest as determined by Streif’s index and starch index. However, fruit from trees on P 22 tended to have less starch and lower F/RS values. At harvest flesh firmness of apples from trees on rootstocks P 22 and P 59 was the highest, respectively the lowest one was observed for M.26 rootstock. Fruits from trees grafted on M.9 and M.26 had the highest mean weight (223 g and 218 g, respectively), whereas P 22 and P 59 – 179 g and 170 g. A negative correlation between fruit size and flesh firmness was observed. After storage and additional shelf life period flesh firmness of fruits from M.9 rootstock was the lowest, while those on P 22 and P 59, like at harvest time, had higher values. Soluble solids content was significantly influenced by rootstock type, especially in 2004. Fruit from trees on rootstocks P 22 and P 59 had high SSC at harvest and at two post storage evaluations. The lowest values for respective time of analysis were noted for fruit from M.9 and M.26, respectively. Titratable acidity was influenced by the rootstock type and the year of study. Higher values were observed in 2004. Rootstock P 59 favoured high TA in ‘Jonica’ fruit. Correlations between studied parameters were established and will be discussed.

Key words: Malus x domestica, fruit size, flesh firmness, soluble solids, acids, Streif’s index.

Introduction. The effect of type of rootstock, on which specific cultivar is raised, on the whole tree performance and fruit quality components are one of the most important issues in fruit science. The decision, which rootstock should be selected for a given planned orchard, is crucial for future orchard management and profitability.
The main objectives of planting trees on vegetative rootstocks are: regulation of tree size, growth rate and crown volume, induction of early bearing and high cropping, adaptation of root system to existing soil and climatic conditions (water deficit tolerance, winter hardiness, etc.). Expected beneficial effect on quality of fruit is often listed at the end of objectives. However, the influence on fruit quality in an existing worldwide overproduction of apples becomes now more important issue.

According to Webster and Hollands (1999), we knew still too little about interactions between rootstock and scion. Rootstock and scion cultivar affect each other mutually, therefore each combination of those components should be treated separately (Schneider et al., 1978). The most commonly used in Europe rootstock M.9 is lately more often criticized (Groot, 1997; Riesen and Husistein, 1998). Studies on similar crown volumes trees suggest that the more dwarfing rootstock the better light penetration and photosynthetic productivity could be observed (Baugher et al., 1994). This logically should influence the whole tree performance and most importantly – fruit quality. According to Kader (1985), quality is a combination of features including appearance, texture, flavour, nutritive value and safety. Consumer demands are already high for flesh firmness and taste (Autio et al., 1996). For citrus fruit the influence of rootstock on quality is already well defined (Castle, 1995). For ‘Jonagold’ fruit (and its sport’s as well) flesh firmness is considered to be the most important parameter, which by 50% decide internal components of quality (Pladett et al., 1992). Soluble solids content and acidity in an equal share contribute to the remaining part of those components. Balanced sugars and acid ratio in apple fruit could provide sweet but refreshing taste. The latter may occur only when appropriate acid content is maintained (Vangdal, 1985; Sekse, 1992). For commercially important apple cultivars such as ‘Jonagold’, there are already known minimal values for their acceptability in a selling period – soluble solids should be within 13–14% and flesh firmness no lower than 45 N (Hoehn et al., 2001).

The objective of our study was to compare the effect of new Polish rootstocks and well-known English ones on the main quality features of ‘Jonica’ apples.

**Materials and methods.** The experiments were carried out on ‘Jonica’ trees planted on rootstocks of Polish selection: P 22, P 59, P 60 and of Malling Series: M.26, M.9. The studies were realized in the period of the beginning of full production capacity of the experimental orchard (4–6 years after planting). Trees were planted at a spacing of 4 x 1.2 m, in four, 5 trees per each replication. Each 6th tree in a row was a pollinator – ‘Šampion’. All trees were trained as slender spindle. From the middle of September, fruits from boundary rows around experimental plots were sampled in weekly intervals for optimum harvest date evaluation. Fruits were picked when Streif’s harvest index values calculated according to formula F(RS) <i>1</i> were within recommended range (Streif, 1983). Mean fruit size (as weight in grams) and percent of blush coloured area were evaluated on a 100 fruit sample. Fruit quality evaluation and analysis (fruit flesh firmness, soluble solids content, titratable acidity, starch pattern, etc.) were carried out according to standard methods (Johnson, 1992). The analyses were performed at optimum harvest date and respective ones after storage for 6 months,
followed by simulated shelf life period of 7 days at 20°C. Fruits were stored in a conventional refrigerated room at 1–2°C, 90–92% RH for 180 days.

Results were subjected to the analysis of variance using Duncan’s Multiple Range test. Tables contain means for 2 consecutive seasons (2003 and 2004), since similar relationships were observed during both years of study.

**Results and discussion.** On the average, fruit size, expressed on a weight basis of apples from trees on studied rootstocks (Table 1) were within or slightly below optimal for consumption for ‘Jonica’ (200–220 g). However, trees on M.9 tended to produce significantly larger fruits and on P 22 – smaller ones. Fruits from trees grafted on M.9 and M.26 had the highest mean weight (223 g and 218 g, respectively), whereas these on P 22 and P 59 – 179 g and 170 g. The results for rootstock M.9 were in agreement with other reports (Babalar and Primoradian, 1996; Groot, 1997), and seemed to be non-dependent on crop volume (within optimum range) as suggested by Ferguson and Watkins (1992). Webster and Hollands (1999) and Pätzold and Fisher (1991) also report about the smallest fruits from trees on P 22.

Very little information exists on the importance of seed number in apple fruit so far. However, taking into account physiological involvement of seeds in Ca uptake and transport into apple fruit this phenomena deserves more attention. The most numerous seeds were present in fruits from trees on rootstock P 60, where also high fruit Ca was observed (data not published).

<table>
<thead>
<tr>
<th>Rootstock Poskiepis</th>
<th>Fruit size Seed number</th>
<th>Blush area</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vaisių dydis, g</td>
<td>Sėklų skaičius, vnt.</td>
<td>Pardalio plotas, %</td>
</tr>
<tr>
<td>M.9</td>
<td>223 e</td>
<td>4.7 c</td>
<td>60 ab</td>
</tr>
<tr>
<td>M.26</td>
<td>218 d</td>
<td>4.3 ab</td>
<td>63 a</td>
</tr>
<tr>
<td>P 22</td>
<td>179 b</td>
<td>4.6 bc</td>
<td>71 b</td>
</tr>
<tr>
<td>P 59</td>
<td>170 a</td>
<td>4.0 a</td>
<td>66 ab</td>
</tr>
<tr>
<td>P 60</td>
<td>197 c</td>
<td>4.8 c</td>
<td>60 a</td>
</tr>
</tbody>
</table>

*Means within columns followed by the same letter do not differ at α = 0.05
* Tarp skiltyse ta pačia raide pažymėtų skaičių nėra esminių skirtumų, kai α = 0.05.

In practical terms there was no effect of rootstock on area covered by blush of ‘Jonica’ fruit. All fruits satisfy minimal requirement for that cultivar to be classified according to EU standards at Class I (at least 1/3 of skin area covered by blush). In other studies with vigorous cultivars, such as ‘Jonica’, fruits from trees on P 22 were having more % blush than on other rootstocks (Autio et al., 1996; Baab, 1998). Our study confirms those earlier results. In some other experiments better coloration was also observed for fruits from trees on MM.106, while in others – on the most dwarfing M.27 (Drake et al., 1991).
Table 2. Fruit flesh firmness, starch index, Streif’s index, total soluble solids and titratable acidity of ‘Jonica’ apples as affected by rootstocks at harvest

There was no evident effect of rootstocks on fruit maturity at harvest as determined by Streif index and starch index (Table 2). However, fruits from trees on P 22 tended to have less starch and lower F/RS values. At harvest flesh firmness of apples from trees on rootstocks P 22 and P 59 was the highest. Respectively, the lowest ones were observed for M.26 rootstock. In opposition to those findings, in both reports of Drake et al., (1991) and Autio (1994) it was evident that the more dwarf rootstock the higher fruit flesh firmness. According to Johnson (1992), rootstock and flesh firmness are indirectly related through a negative correlation – fruit size and flesh firmness. Presented study seems to confirm such relationship, small apple fruits originating from trees on P 22 rootstock were having the highest flesh firmness at harvest.

‘Jonica’ fruit from trees on rootstock M.9 reached harvest maturity usually 3–5 days earlier than on other rootstocks (unpublished results), and tend to obtain the lowest values of Streif’s index for fruits from trees on P 22.

Rootstock did affect the content of carbohydrates and organic acids (Table 2). Soluble solids content was the highest for fruits from trees on P 22 and P 59. This confirm the results of Autio et al., (1996), who stated that fruits from trees on rootstocks from P series tended to contain more soluble solids than from M.26 or M.9, respectively. Results of cited above author and of our study are in opposition to earlier reports stating that fruits from trees on M.9 and M.26 tended to have more soluble solids (Autio 1994). Some authors claimed that soluble solids content was negatively correlated to trunk cross sectional area (Autio et al., 1996). Such tendency could be observed in a reported study only for fruit from trees on P 22 and P 59.
Table 3. The effect of rootstocks on fruit flesh firmness, total soluble solids and titratable acidity of ‘Jonica’ apples after storage and simulated shelf life period of 7 days at 20°C

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Flesh firmness minkštimo kietumas, kg cm⁻²</th>
<th>Total soluble solids tirprios sausosios medžiagos, %</th>
<th>Titratable acidity (mg malate 100 g⁻¹)</th>
<th>Flesh firmness minkštimo kietumas, kg cm⁻²</th>
<th>Total soluble solids sausosios medžiagos, %</th>
<th>Titratable acidity (mg malate 100 g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.9</td>
<td>5.1 b</td>
<td>12.1 a</td>
<td>292 cd</td>
<td>4.8 b</td>
<td>12.3 c</td>
<td>234 n.s.</td>
</tr>
<tr>
<td>M.26</td>
<td>4.9 a</td>
<td>12.0 a</td>
<td>301 d</td>
<td>4.7 a</td>
<td>11.9 a</td>
<td>247</td>
</tr>
<tr>
<td>P 22</td>
<td>5.6 e</td>
<td>13.0 d</td>
<td>253 a</td>
<td>5.1 d</td>
<td>12.7 d</td>
<td>230</td>
</tr>
<tr>
<td>P 59</td>
<td>5.5 d</td>
<td>12.8 c</td>
<td>275 b</td>
<td>5.1 d</td>
<td>12.5 d</td>
<td>258</td>
</tr>
<tr>
<td>P 60</td>
<td>5.4 c</td>
<td>12.3 b</td>
<td>287 bc</td>
<td>4.9 b</td>
<td>12.1 b</td>
<td>253</td>
</tr>
</tbody>
</table>

After storage in optimal conditions for 180 days ‘Jonica’ apples in general satisfy quality criteria for Class 1 or Extra (Table 3). The results have shown that rootstocks influenced the quality of fruits after storage and additional period of simulated shelf life. The maintenance of ‘Jonica’ apple flesh firmness after storage for 180 days and 7 days at 20°C was the best for fruits from trees on P 22 and P 59. Drake et al. (1991), however, observed such tendency for fruits from trees on more vigorous rootstocks. Fruits from all rootstocks/scion combinations in our study maintained after storage flesh firmness above 4.5 kg. This should satisfy consumers’ minimal requirements of 45 N for fruit acceptability as indicated by Pocharski and Konopacka (1999) and Hoehn et al. (2001). However, Goffings and Herregods (1994) suggested slightly higher value of 5 kg. The retention of total soluble solids (TSS) after storage and a period of simulated shelf life reflected the relationships observed at harvest time (Skrzyński, 2006). There were on the average 1% smaller values of TSS, which is a common result after storage in regular air. The best retention of titratable acidity was for fruit from trees on rootstocks of M. series after storage. After additional 7 days at room temperature fruits from trees on P 59 and P 60 tended to have higher titratable acidity.

Fruits from those rootstocks may fully satisfy consumer expectations for fresh consumption due to balanced sugars and acids content as suggested by Vangdal (1985) and Sekse (1992). It was not confirmed that in general apples from trees on rootstock M.26 tend to produce fruits with more balanced components (Vangdal, 1985).

Conclusions. 1. The effects of rootstocks on the main fruit quality attributes at harvest were significant.
2. Rootstocks affect ‘Jonica’ fruit quality retention after storage and shelf life.
3. Trees on P60 and M.9 were of balanced vigor and fruits from those trees were of the best quality.
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References


Reikšminiai žodžiai: Malus x domestica, vaisių dydis, minkštimo kietumas, tirpių sausosios medžiagos, rūgšties, Streifo indeksas.