Fruit Morphological Changes during Pit Hardening in Autochthonous Istrian Olive (*Olea europaea* L.) Cultivars

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Summary

Endocarp lignification is important fruit growth phenophase since after its completion fruit starts with oil accumulation. The information about duration of endocarp lignification is important for timing of management practices, irrigation and pest control in oil cultivars, and fruit thinning in table cultivars to obtain uniform fruit weight and size.

In this study, fruit length, width and weight of four Istrian autochthonous olive cultivars ('Buža', 'Puntoža', 'Rošinjola' and 'Istarska bjelica') were measured. Samples were taken from olive collection orchard of the Institute of Agriculture and Tourism in Poreč in equal growing conditions.

The aim of the research was to define an olive fruit growth dynamics during pit hardening. Fruit weight in all cultivars was increasing during endocarp lignification (from 7th to 28th July). The highest percentage in the weight growth in the first week had cultivars 'Buža' (48.5%) and 'Rošinjola' (44.6%) while in the second week maximum was reached by cultivars 'Puntoža' (44.2%) and 'Istarska bjelica' (42%). The highest increase in total fruit mass was detected in 'Puntoža' (1.30 g) and the least at 'Rošinjola' (0.56 g). Maximum increase in length (L) and width (W) had 'Puntoža' (L: 7.13 mm; W: 4.23 mm) and the least 'Istarska bjelica' (L: 2.48 mm; W: 2.70 mm).

Key words

olive fruit, pit hardening, phenology

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Introduction

Olive oil from autochthonous olive cultivars is highly valued by consumers and used for olive oil brand management by producers (Poljuha et al., 2008a). According to available data, 'Buža' (50.7%) dominates in old Istrian olive orchards, followed by 'Istarska bjelica' (30.2%) and 'Rošinjola' (5.7%) (Milotić and Šetić, 2005).

When fruit is fully developed, fruit of 'Buža' weights about 4.38 g, 'Puntoža' 4.25 g, 'Istarska bjelica' 3.09 g and 'Rošinjola' 2.09 g (Poljuha et al., 2008b).

Olive fruit is composed of four main parts: exocarp or skin, mesocarp or flesh, which is an edible part of table olives and part where olive oil accumulation starts, and lignified endocarp, which surrounds and protects an olive semen or seed. Endocarp development is completed 8 to 10 weeks after bloom (Rapoport et al., 2004a). After that, an intensive mesocarp development begins that increases its transverse area about twice form 8 to 15 weeks after bloom (Gucci et al., 2009).

Some authors suggest that in olive fruits double sigmoid pattern was not found (Hammami et al., 2011; Trentacoste et al., 2010; Lavee et al., 2007). Slowdown of the olive fruit growth is associated with pit hardening (Gucci et al., 2009). Phenophase appearance is mainly related to environmental conditions (temperature and precipitation) and to genetic characteristics of cultivar (Koubouris et al., 2010; Corelli-Grappadelli and Lakso, 2004).

Precise determination of olive fruit development phases is important because of irrigation management and plant protection interventions in olive orchard.

Pit hardening is a continuous and progressive process and length of this period can vary according to water status (Rapaport et al., 2004b). Pit hardening phenophase is important because, after its completion, a marked tryacylglycerol (TAG) accumulation in olive fruit pulp begins (Galla et al., 2009; Lavee and Wonder, 2004).

Identification of pit hardening stage is useful in orchard management and timing of cultural practices: irrigation (Gucci et al., 2009; Pérez-López et al., 2008), plant protection (Lykouressis et al., 2004), plant nutrition (Morales-Sillero et al., 2008) and fruit thinning (Dag et al., 2010). Several authors have suggested that flower bud induction occurs at around the time of pit hardening (Sanz-Cortés et al., 2002; Andreini et al., 2008).

There are limited information in the literature about the timing and duration of fruit growth phenophases for autochtonous Istrian cultivars. Therefore, the aim of this study is to document length, width and weight of four Istrian autochthonous olive cultivars ('Buža', 'Puntoža', 'Rošinjola' and 'Istarska bjelica').

Materials and methods

Research was carried out in the olive collection orchard of the Institute of Agriculture and Tourism in Poreč, Croatia (N 45°13'19"; E 13°36'12") on autochthonous olive cultivars 'Puntoža', 'Rošinjola', 'Buža' and 'Istarska bjelica'.

From each cultivar, ten fruits in four weekly periods from 7th to 28th July 2010 were randomly collected from middle part of growing shoot.

Weight was measured on laboratory balance GX-600 (A&D Weighing, Japan). After weight measurements, fruits were cut longitudinally with sharp razor on two symmetrical parts which are then pictured by digital microscope DinoLite Pro – AM413T (ANMO Electronics Corp., Taiwan). Length and width were measured on longitudinally sections with DinoCapture software (ANMO Electronics Corp., Taiwan).

Fruit shape and symmetry were determined according to Methodology for characters of the fruit (Methodology for Primary Characterisation of Olive Varieties, 1997).

Data analysis was performed using Statistica 5 software. To test the significance of variation among cultivars, analysis of variance (ANOVA) and Tukey honest significant difference (HSD) comparison test were performed.

Results and discussion

During monitoring period the highest total length growth had 'Puntoža' (7.13 mm) while the least growth was observed in 'Istarska bjelica' (2.48 mm). 'Puntoža' and 'Istarska bjelica' through whole monitoring period had an elongated fruit shape, while 'Buža' and 'Rošinjola' in first three weeks had an elongated shape and in last measurement (28th July) shape was ovoid. 'Rošinjola' and 'Istarska bjelica' fruits changed its shape from

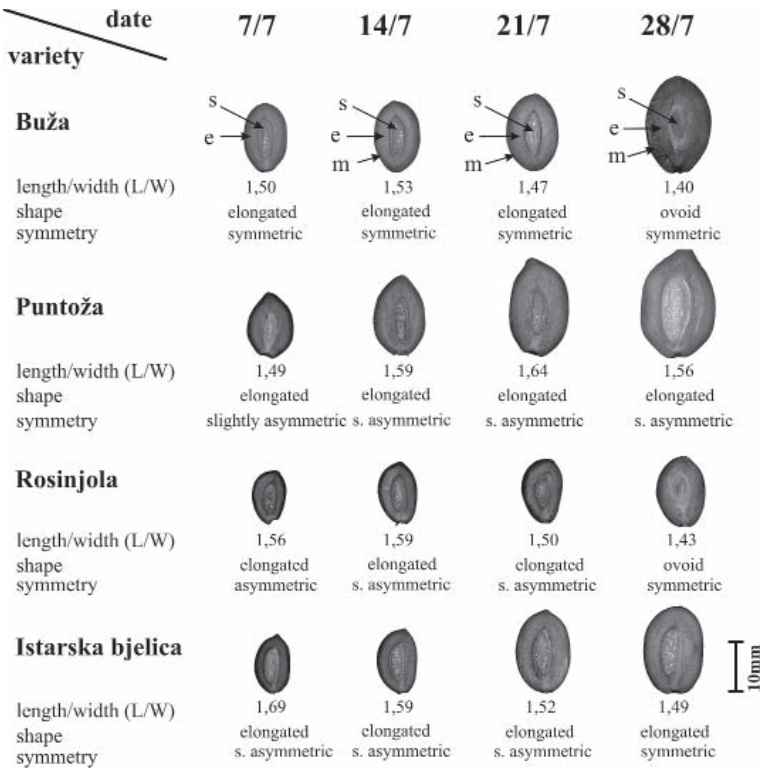

Figure 1. Morphological changes during pit hardening phase in four autochtonous Istrian olive cultivars (s-seed, e-endocarp, m-mesocarp)

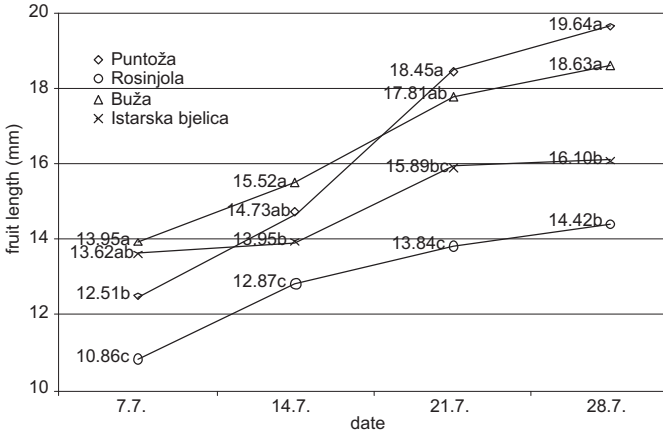

Figure 2. Fruit length changes during pit hardening phase in four autochtonous Istrian olive cultivars (Significant differences between cultivars are presented with different letters ($P \leq 0.05$) according to the Tukey's HSD test)

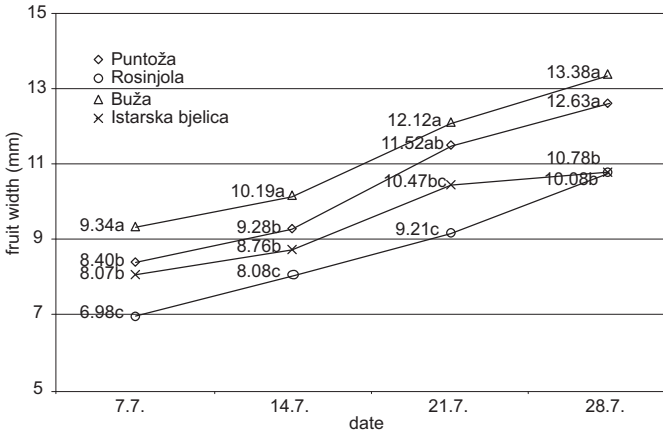

Figure 3. Fruit width changes during pit hardening phase in four autochtonous Istrian olive cultivars (Significant differences between cultivars are presented with different letters ($P \leq 0.05$) according to the Tukey's HSD test)

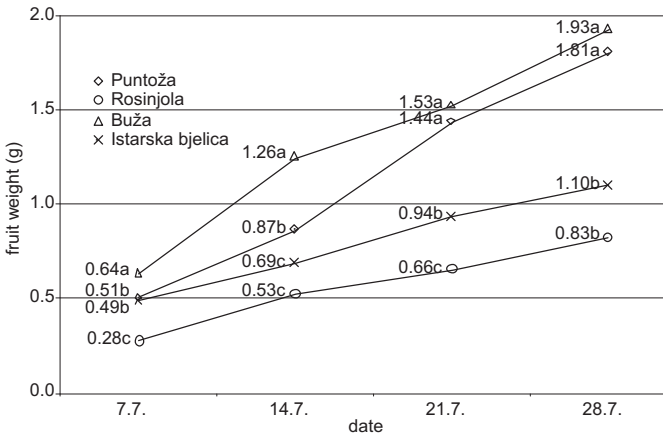

Figure 4. Fruit weight changes during pit hardening phase in four autochtonous Istrian olive cultivars (Significant differences between cultivars are presented with different letters ($P \leq 0.05$) according to the Tukey's HSD test)

Table 1. The percentage of mesocarp in relation to total fruit width in four autochtonous Istrian olive cultivars

Cultivar	Date			
	7.7.	14.7.	21.7.	28.7.
Puntoža	44.40%	41.40%	49.70%	51.70%
Rošinjola	40.40%	40.10%	42.10%	43.70%
Buža	44.00%	47.80%	51.50%	55.80%
Istarska bjelica	40.40%	40.80%	49.50%	50.20%

slightly asymmetric to symmetric while 'Buža' (symmetric) and 'Puntoža' (slightly asymmetric) had the same shape through monitoring period (Figure 1). In fully developed fruits 'Buža' has spherical and symmetrical fruits; 'Puntoža' has oval and asymmetrical, while 'Istarska bjelica' and 'Rošinjola' have oval and symmetrical fruits (Poljuha et al., 2008). According to our results during pit hardening period olive fruits pass through intensive morphological changes, but those changes are not same in all researched cultivars and shape was different compared to fully developed fruits.

The highest total width growth had also 'Puntoža' (4.23 mm) and the least 'Istarska bjelica' (2.70 mm). In total fruit weight the highest mass growth had 'Puntoža' (1'30 g) and the least 'Rošinjola' (0.56 g).

In the first week, the highest fruit length had 'Rošinjola' (2.01 mm) while in the second week it was 'Puntoža' (3.72 mm), 'Buža' (2.28 mm) and 'Istarska bjelica' (1.94 mm) (Figure 2.).

All cultivars showed the highest width growth in the second week, 'Puntoža' (2.24 mm), 'Buža' (1.92 mm), 'Istarska bjelica' (1.71 mm) and 'Rošinjola' (1.14 mm) (Figure 3).

The highest percentile growth based on fruit weight at the end of pit hardening phase in the first week had 'Buža' (48%) and 'Rošinjola' (45%) while in the second week 'Puntoža' (44%) and 'Istarska bjelica' (41%).

At the end of pit hardening phenophase there were no significant differences ($P \leq 0.05$) in fruit length, width and weight between 'Puntoža' and 'Buža' and also between 'Istarska bjelica' and 'Rošinjola' (Figures 2, 3 and 4).

In the period of eight weeks after full bloom both mesocarp and endocarp width increase, with more rapid endocarp growth (Rallo and Rapoport, 2001). The percentage of mesocarp in relation to total fruit width, in our study for researched cultivars was similar to Manzanilla olive cultivar reported by Rallo and Rapoport (2001) (Table 1).

Comparison of our results of fruit weight measurement at the end of pit hardening phase and fruit weight measurements in fully developed olive fruits (Poljuha et al., 2008b) brought to a conclusion that 'Buž'a at the end of pit hardening phase achieves 44% weight of fully developed fruit, 'Puntoža' (43%), 'Istarska bjelica' (36%) and 'Rošinjola' (40%).

In our study we didn't notice olive fruit double sigmoid growth, because of continuous fruit and mesocarp growth during pit hardening phase and those results are in accordance to Hammami et al. (2011).

Conclusions

Precise determination of pit hardening phase by non-destructive morphological fruit measurements can be useful for decision making about agricultural practice, especially plant protection, nutrient and water supply.

Since researched cultivars didn't show the same pattern of fruit growth and endocarp development, knowledge about growth pattern is important for olive orchard management.

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