

THE INFLUENCE OF PRE-HARVEST TREATMENTS ON FRUITS QUALITY OF APPLE CULTIVARS (*MALUS DOMESTICA* BORKH.)

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Abstract

Apples fruit quality is mainly influenced by biotic and abiotic factors. Various possible pomological approaches are able to improve fruit quality and market value. Among these, techniques of fruit bagging and summer pruning have become an integral part of pomological practises in many countries, because it is a safe and eco-friendly technique to protect fruits from multiple stresses, preserving or improving the overall quality. The bagging consists essentially of enclosing a young fruit in a cardboard bag. Isolating the fruit from the external environment protects it during development from mechanical or biotic damage, especially in regions where fruits are prone to attacks by fungi, bacteria, insects and even birds. The expected increasing fruit skin color in comparison to non-bagged fruits can therefore correspond either to a reduction or an increase in color or even a greater homogeneity of the color itself.

The aim of this research was to determine how the application of post-harvest aids affects the quality of fruits and storage capacity of three cultivars of late-ripening apples (Breaburn, Fuji and Pink Lady). Applying summer pruning and covering apple fruits with cardboard bags has a positive effect on increasing the surface of the complementary color on the skin of the fruit. In addition, the influence of these measures on the physical and chemical properties of the fruits after harvest and storage for a period of four months was examined.

The experiment was set up in 2019 in a completely randomized design with five replications in the nine leaves old orchards of the Faculty of Agriculture in Belgrade. The used pre-harvest treatments influenced the increase in yield, fruit firmness, and chemical composition. The summer pruning of branches four weeks before harvesting significantly improve percentage of fruit skin color to all examined cultivars, while bagging of fruits only had increased of fruit skin to cultivar Breaburn.

Key words: *apple, bagging, fruit skin color, summer pruning*

INTRODUCTION

Apple (*Malus x domestica* Borkh.) in the world is the most produced temperate tree fruit due to as well as internal and external traits qualities, such as fruit shape, size, and surface color, texture and the levels of sugars, organic acids, and phenolic compounds (Feng et al., 2014). Apple is the most important of the deciduous tree fruits in Serbia in last decade, with annual production of about 450.000 tonnes. The intensive orchards have been proposed to improve profitability and yield, but possible barrier

for increased fruit consumption is insufficient fruit quality (Djordjevic et al., 2018). Pruning is one of the main management practices in the farming of fruit trees (Demirtas et al., 2010). Nevertheless, tree form like a tall spindle planting system maximizes profitability of apple and producers let them grow up to 4 m in order to produce more fruits (Yang et al., 2015). However, after a few years of planting a decreased of amount of sunlight reached the lower canopy due to the shading of the lower parts of the

canopy were recorded. A thereby reducing fruit yield and quality because of decreased of light penetration especially in the lower and interior parts of the canopy arises as a consequence of densely planted, tall, and vigorous trees (Mierowska et al., 2002). Summer pruning is a one of most used practices in modern orchard to improve light intensity, especially of extended and vigorous shoots (Lakso and Corelli, 1993). Used a summer pruning techniques enhance fruit quality, and regulate the size and apple trees (Mika and Buler, 2015). Response of apple trees to summer pruning depended of cultivar, age, and nutritional status; and by pruning inherent factors, such as time of execution, type, and intensity (Li et al., 2003).

Red colored apples are preferred in the market as these attract the consumers. However, at poored environmental conditions, color development is not adequate (Sharma et al., 2013).

According many of researchers the pre-harvest fruit bagging has emerged as one of the best approaches to improve

fruit visual quality. In this technique an individual fruit is bagged on the tree for a specific period to get desired results. This pre-harvest technique also enhances internal fruit quality and has a physical protection against insects and pest (Kitagawa et al., 1992; Hofman et al., 1997; Amarante et al., 2002). However, some authors have reported contradictory results for the effects of pre-harvest bagging on fruit size, flesh mineral content, maturity stage, peel color and fruit quality (Fan and Mattheis, 1998). The reasons could be to differences in the type of bag used, the stage of fruits development when they were bagged, duration of fruit exposure to natural light after bag removal in front of harvesting time, and cultivar-specific response.

The aim of this research was to determine how the application of pre-harvest techniques, such as summer pruning and bagging of fruits, affects on quality of fruits and storage aviability of three cultivars of late-ripening apples (Breaburn, Fuji and Pink Lady).

MATERIALS AND METHODS

This research was conducted using nine-year-old late ripening cultivars 'Breaborn', 'Fuji' and 'Pink Lady' grafted on M.9 (*Malus x domestica* Borkh) in a commercial high-density orchard located in Research Station of Faculty of Agriculture during 2021. The experiment was conducted by a random field with four repetitions (five trees were taken from a repeat). A total of 20 trees per cultivars and treatments were used in this experiment were approximately 3.5 m tall and planted at a spacing of 3.3 × 0.8 m (3.600 trees/ha) in north to south orientation and growing on tall spindle form of trees. The trees were grown in deep loam soil and managed with a conventionally fertilizer and a pest control program. Summer pruning was applied on a month before harvesting of fruits. The bagging was done about a month before harvesting (in same times like

summer pruning) and removed 7-day before harvesting. No pruning trees and non bagging fruits for these trees were used as a control treatment. After harvesting fruits were stored at 2°C ± 1°C and 90% - 95% RH.

The research included the following physical traits of fruits: mass of fruit (g), a diameter of fruit (mm), percentage of radish of fruits and firmness (kg/cm²). Also, evaluated chemical properties of fruits: soluble solid contents (SSC) and total acids (TA). For the determination of the ripening stage, the Streif index (SI) considering starch, soluble solid contents and firmness was implemented to reduce subjectivity (Streif, 1996). Physical properties of fruits were determined with four repetitions, and each repetition included 20 fruits. Chemical properties were determined with three repetitions. The physical properties were determined

used standard morphometrics methods. SSC was determined by refractometer (Atago, pocket PAL-1. Kyoto, Japan). Titratable acidity (TA) was determined by titrating 25 g of berries with 0.1N NaOH up to pH 7.0 in %. After storage of five months in cold storage on fruits were recorded following changes: decreased of

mass (%), decreased of firmness (%), decreased TA (%) and increased of SSC (%) and color of fruits (%). Analysis of variance has been done with STATISTICA 9 software package. The significant differences between means determined at $P < 0.05$, measured with LSD test.

RESULTS AND DISCUSSION

Used pre-harvest treatments had significantly effects to physicals and chemicals properties of fruits (Table 1). The highest fruit mass had cultivar 'Breaburn', while 'Pink Lady' had the

smallest. To the all cultivars the highest mass of fruits were recorded in treatment with summer pruning, while the smallest mass of fruits were in bagging treatment.

Table 1. Effects of treatment on physical and chemical quality of fruits

Cultivar	Treatment	Fruit mass (g)	Diameter (mm)	Color (% red)	Firmness (kg/cm ²)	Iodine scale (1-5)	SSC (% brix)	TA (%)	Streif index
Fuji	Bagging	186.3 b	72.4 bc	56.0 b	7.5 b	3.9	15.1	0.8	0.07
	Pruning	207.9 ab	77.5 a	51.8 b	8.1 ab	3.2	17.1	0.9	0.07
	Control	202.2 ab	78.3 a	52.3 b	7.3 b	3.8	15.2	0.9	0.06
Breaburn	Bagging	178.2 bc	71.9 bc	44.5 b	9.3 ab	3.5	14.1	0.6	0.12
	Pruning	216.9 a	74.4 b	54.5 b	9.9 ab	2.9	13.5	0.7	0.12
	Control	201.6 ab	71.5 c	66.8 a	7.8 b	3.3	13.2	0.8	0.09
Pink Lady	Bagging	150.5 c	70.2 cd	71.8 a	9.6 ab	3.9	21.5	0.4	0.06
	Pruning	161.5 c	71.2 c	79.0 a	10.2 a	3.8	19.8	0.7	0.08
	Control	151.5 c	68.3 d	76.2 a	9.5 ab	3.2	15.5	0.7	0.10
Isd 0.05		21.4	2.3	12.5	2.1				

Data are means of 4 replications; Different between cultivars and treatments were done according to least significant difference test (LSD) at $p < 0.05$, level.

Results of the study have revealed that fruit bagging and summer pruning did not have significantly influenced the color development in apples. Average the highest percentage of color skin had fruits of cultivar 'Pink Lady', while the smallest had fruits cultivar 'Fuji'. This difference between cultivar 'Pink Lady' and others cultivars was statistical significant. Values of this trait varied and depend by environmental conditions and genotypes (Ceymann et al., 2012; Chen et al., 2012). Also, earlier studies have reported that fruit bagging in apple inhibited color development, but has now been established that fruit bagging is an effective way to promote anthocyanin

synthesis and improve fruit coloration in apples (Sharma et al., 2013).

The cultivar 'Pink Lady' had the highest values of fruits firmness. To the all cultivars were noticed the higher values of this trait in treatment with summer pruning. Wang et al. (2011) recorded that management practices had strong influence to firmness of fruits. Cultivar 'Pink Lady' also had fruits with higher contents of soluble solids compared to others cultivars. To the all cultivars control trees had fruits with the lowest soluble solid contents. The bagging treatment decreased the starch concentrations for flesh compared to other treatment and control trees, and

similar results were recorded Feng et al. (2014).

After storage of five mounts in cold storage fruits had significant changes of their physical and chemical properties (Table 2.). To the all cultivars three of five

traits had decreased of values, while to two traits were recorded increased of values. The highest decreased of fruit mass had cultivar 'Breaburn', while the smallest had cultivar 'Pink Lady'.

Table 2. Effects of treatments on fruit quality after storage

Cultivar	Treatment	Decreased mass (%)	Decreased firmness (%)	Decreased TA (%)	Increased SSC (%)	Increased Color (% red)
Fuji	Bagging	7.5 ab	20.1 b	70.3 a	6.6 b	12.4 bc
	Pruning	9.3 ab	23.9 b	69.4 a	4.7 b	9.5 bc
	Control	9.3 ab	6.4 c	41.6 b	10.5 ab	7.2 c
Breaburn	Bagging	11.8 a	36.8 a	34.2 b	14.6 a	15.4 b
	Pruning	9.3 ab	29.4 ab	66.2 a	12.6 ab	10.2 bc
	Control	9.9 ab	34.6 ab	46.2 b	9.8 ab	9.1 bc
Pink Lady	Bagging	7.3 ab	22.4 bc	36.7 b	4.7 b	21.8 a
	Pruning	4.4 b	31.0 ab	46.2 b	11.6 ab	15.3 b
	Control	4.8 b	14.3 bc	33.8 b	15.5 a	9.5 bc
Isd 0.05		5.6	11.2	24.5	7.5	6.2

Data are means of 4 replications; Different between cultivars and treatments were done according to least significant difference test (LSD) at $p < 0.05$, level.

However, significantly difference between treatments did not notice. Cultivar 'Breaburn' had significantly higher decreased of firmness of fruits after storage. Also, on this trait used treatment had significant effects. The differences between treatments in fruit firmness were increased, where notice that fruits from bagged and pruning trees had more substantial were softening than fruit from control trees. Ours results are confirming with previously research (Amarante et al., 2002). Leaf removal by pruning during the growth cycle reduces the carbohydrate and nutrient accumulation in the remaining organs (Ikinci et al., 2014). The rate of carbohydrate and together with the capacity for photosynthetically active radiation are an essential factors for apple production and fruits quality

CONCLUSION

This study confirmed that applied pre-harvest techniques had significantly effects on physical and chemical

(Demirtas et al., 2010). The highest percentage decrease of values in fruits after storage was recorded to content of total acids. This decrease was ranged between 33.8% to 69.4%. The highest decreased had cultivar 'Fuji'. Also, between treatments was noticed significant difference. During storage of five mounts to all cultivars was recorded increase of soluble solid contents and surface color. A fruits from control trees had higher increased of soluble solid contents, and between treatments did not notice significantly difference. The highest increased of surface color had cultivar 'Pink Lady', while smallest had 'Fuji'. However, to all cultivars bagging fruits had higher increase of this trait, which is in agree with previously research (Sharma et al., 2014b)

properties of fruit of three investigated cultivars. Summer pruning and bagging fruits, compared to control fruits, improve

following quality of fruits in moment of harvesting: firmness of fruits and soluble solid contents. Also, it should be pointed out that a bagging improve colored of

fruits surface after storage to all cultivars. On the other hand, applied treatments were decreased values of fruits firmness and total acids after storage.

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