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INFLUENCE OF ROOTSTOCKS AND STORAGE CONDITIONS ON THE QUALITY OF SWEET CHERRY FRUITS 'REGINA'

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Abstract. Rootstock modifies many fruits features during growth and cropping trees in the orchard. Studies were undertaken to prove the effect of rootstock on the quality of sweet cherry 'Regina' fruit before and after storage period. Experiment was conducted in storage conditions – normal atmosphere at 8°C and 2°C and controlled atmosphere – 3% O_2 + 5% CO_2 at 2°C. In two seasons, 2011 and 2012 fruits samples are harvested at maturity stage and stored for two weeks. After harvest the fruits were evaluated for firmness, soluble solids content and titratable acidity and after storage for firmness, soluble solids content and titratable acidity, the loss of fruit mass, changes of fruit peduncle color, percent of decay fruit. Both rootstocks and storage regime affected majority of the investigated parameters. The effect of rootstock was varied and depended on year of experiments; however, fruit from Tabel-Edabriz rootstock exhibited the highest soluble solids content in both years. Fruits from CA 2°C were the most firm, exhibited the highest acidity and the least percent of fungal decay symptoms. In turn, fruits from NA 8°C were characterized by the highest soluble solids content and SSC/TA ratio. Storage under CA 2°C caused the least loss of fruits weight.

Key words: controlled atmosphere, firmness, soluble solids content, titratable acidity, fruit decay

INTRODUCTION

Global world sweet cherry fruits decisively passed 2 million metric tons, and are headed for 3 million. Growing of the tress and fruits production is carried out in many countries, on both hemispheres. Sweet cherry is perishable fruit, is gathered in a stage of consumption maturity, similar to plum [Candan et al. 2011] and opposite to the apple

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[Hărsan et al. 2006] and is characterized by a high content of water in the tissues, a thin skin and high intensity of respiration, (35–55 mg CO_2 kg fruits per h) [Crisosto et al. 1993]. Due to the excellent taste and high nutritional values, sweet cherry fruits are highly appreciated by consumers. Since sweet cherry is consumed mainly as a dessert fresh fruit prolongation of fresh fruit supply on market by using the technology of short cool storage is often applied. Yet, the sweet cherry fruit can be stored for a relatively short time (up to 8 weeks) at ensuring the optimal storage conditions. Lately, studies concerning new technology storage (modified atmosphere packaging, air and water precooling) are conducted [Remón et al. 2000, Giacalone and Chiabrando 2013].

The flavor of sweet cherry fruits is largely depended on ratio of soluble solids content to titratable acidity (SSC/TA); however, during the cool storage acidity and soluble solids are changed, influencing the taste of the fruit [Drake and Fellman 1987, Meheriuk et al. 1995]. Cherry have no starch reserves, therefore maintenance of respiration relies primary upon organic acids [Singh et al. 1970, Sekse 1988]. Also the fruit firmness, which is affected by postharvest fruit softening, is important fruit quality factor [Brown and Bourne 1988].

The rootstock used for fruit trees growing affects many tree and fruit traits. Dwarf and semi-dwarf rootstocks for sweet cherry can influence the tree vigor [Balmer 2008], regular bearing [Grzyb et al. 1998], index of productivity [Bielicki and Rozpara 2010], mass of fruit [Gratacós et al. 2008], cracking susceptibility [Sekse 1998] and quality of fruit, both at harvest and postharvest period. These include size, firmness, soluble solids content, acidity, color (fruit, peduncle) and taste [Simon et al. 2004, Gratacós et al. 2008, Kankaya et al. 2008].

Sometimes vitamin, polyphenols and anthocyanin content in fruit can be affected by rootstock as well [Spinardi et al. 2005]. Trees of different vigor can produce sweet cherry fruits with different phenolic acid and flavonol content. Wild growing sweet cherry genotypes have different nutritional properties and are relatively higher in blackish skin colored fruits than in light skin colored ones [Karlidag et al. 2009]. In available literature only one study, concerning the effect of rootstock on sweet cherry fruit stored, exists [Cavalheiro et al. 2005].

The aim of the presented studies was to evaluate the quality of 'Regina' sweet cherry fruits from trees growing on four different rootstocks after storage in normal and control atmosphere conditions.

MATERIAL AND METHODS

Fruit from the sweet cherry (*Prunus avium* L.) cultivar 'Regina' were harvested during commercial maturity from 9–10 year old trees grown in Experimental Station of Agricultural University, in Garlica Murowana 10 km north of Krakow, 270 m above sea level (50°09' N, 19°56' E) in years 2011–2012. The sweet cherry trees were grown on the following rootstocks: F12/1, Tabel-Edabriz, Weiroot 10 and Damil, which were obtained by tissue culture technology. Trees were planted at 5 × 2.5 m, and had been trained as wide spindle form. Weed control was maintained with herbicides in tree rows and with grass between rows. Sweet cherry cv. 'Kordia' was pollinator in the orchard.

Chemical protection was carried out according to the recommendation for commercial orchards. Fruits were harvested on 5 July 2011 and on 28 June 2012.

Assessment of fruit after harvest. Immediately after harvest, probe of 40 fruits was evaluated for firmness, soluble solids content (SSC), titratable acidity (TA) and SSC/TA ratio. Firmness was determined using TA 500 Texture Analyzer, (Lloyd Instruments Ltd. UK) equipped with an 8-mm probe and values were expressed in Newton's (N). Fruit SSC was determined by a digital refractometer (PR-101, Atago, Tokyo, Japan) at 20°C and expressed in percent. Titratable acidity (TA) was determined by potentiometric titration to pH 8.1 with 0.1 N NaOH, up to pH 8.1 using 5 ml of diluted juice in 100 ml distilled H_2O and results were expressed as percent of malic acid. The color of fruit peduncle was estimated by a visual evaluation according to Royal Horticultural Society's Color Chart (RHS, UK).

Storage conditions. For each treatment fruit specimens (4 × 250 g – 25 fruits each) in plastic containers were stored for two weeks, in following conditions: controlled atmosphere (CA) (5% CO_2 and 3% $O_{2,}$ RH–90%, temperature 2°C) normal atmosphere (NA) (RH–90%, temperature 2ºC), and normal atmosphere (NA) (RH–80%, temperature 8ºC).

Assessment of fruit quality after storage. After storage the following fruit parameters were investigated: fruit firmness, SSC, TA and SSC/TA ratio. Moreover, the loss of fruit weight, maintenance of green color of fruit peduncle, and fungal decay of fruit was visually assessed and expressed in percentage.

Statistical analysis. The experiment was conducted in two seasons, for each combination in four replications. The data were analyzed with ANOVA and calculation was made separately for each season. The values expressed in percent were transformed according to Bliss function ($y = \arcsin \sqrt{x}$). To determine the significance of differences between mean values LSD Fisher test was used, at a significance level of $p \leq 0.05$.

RESULTS

'Regina' sweet cherry fruit was harvested at commercial stage of maturity; date of harvest was estimated based on the fruit size and color. In table 1 has been shown that the rootstocks significantly affected the studied features (fruit firmness, SSC, TA, SSC/TA ratio) at harvest, except the fruit firmness and titratable acidity in one season.

In 2011 season fruit picked from dwarf rootstock Weiroot 10 was firmer than from vigorous F12/1, whereas no difference in firmness was found for fruit from Tabel-Edabriz and Damil rootstocks. The significantly highest SSC content and SSC/TA ratio in both seasons exhibited fruit from Tabel-Edabriz rootstock. Fruit from F12/1 and Weiroot 10 rootstocks contains the most acids, whereas the fruit from Tabel-Edabriz was characterized by the lowest TA. Vigorous F12/1 rootstock significantly lowered the SSC content and SSC/TA ratio comparing to other rootstocks in 2011 year.

After two weeks of storage the investigated rootstocks and storage conditions (i.e. atmosphere and temperature) significantly affected 'Regina' sweet cherry fruit quality in two seasons (tabs 2 and 3).

Table 1. Fruit quality of 'Regina' sweet cherry at harvest as affected by rootstocks

Year	Rootstock	Fruit firmness (N)	Soluble solids content (%)	Titratable acidity (mg 100 g^{-1})	Ratio SSC/TA
2011	F12/1	13.8 a[x]	15.5 a	0.61 ns	25.4 a
	Tabel-Edabriz	15.2 ab	17.0 c	0.59 ns	28.8 c
	Weiroot 10	16.9 b	15.9 b	0.59 ns	26.9 b
	Damil	15.4 ab	16.2 b	0.59 ns	27.5 b
2012	F12/1	21.9 ns	14.8 b	0.74 c	20.0 b
	Tabel-Edabriz	22.9 ns	6.8 d	0.63 a	26.7 c
	Weiroot 10	22.3 ns	12.0 a	0.73 c	16.4 a
	Damil	22.4 ns	16.1 c	0.71 b	22.7 b

[x] – within a column values followed by the same letter are not significantly different at α = 0.05, calculation was made separately for each year

Table 2. Fruit quality of 'Regina' sweet cherry after 2 weeks of air and controlled atmosphere storage (2011 year)

		df[y]	Firmness (N)	SSC (%)	TA (mg 100 g^{-1})	SSC/TA	Fungal decay (%)
Rootstock (A)	F12/1		12.6 n.s.[x]	15.9 b	0.49 ns	32.9 a	11.3 c
	Tabel-Edabriz		13.5 n.s.	16.4 c	0.50 ns	33.2 b	9.3 b
	Weiroot 10		12.8 n.s.	15.4 a	0.49 ns	31.5 a	21.5 d
	Damil		13.0 n.s.	16.1 b	0.50 ns	31.7 a	4.2 a
Storage conditions (B)	NA 8°C		11.7 a	16.4 b	0.45 a	35.8 b	13.2 b
	NA 2°C		13.0 b	15.7 a	0.51 b	30.7 a	12.3 b
	CA 2°C		14.1 c	15.6 a	0.52 b	30.6 a	9.3 a
Significance	A	3	n.s	–	n.s.	–	–
	B	2	–	–	–	–	–
	A × B	6	–	–	n.s.	–	–

[x] – within a column, values followed by the same letter are not significantly different at α = 0.05
[y] – degrees of freedom

The effect of rootstock on fruit firmness was significantly proved only in the second season. Fruits from trees cultivated on Damil rootstock were firmer, while from trees cultivated on F12/1 rootstock were the softest among the studied rootstocks. Storage conditions significantly affected the fruit firmness in both seasons. The firmest fruit was found after storage in CA, while the softest in NA at temperature 8°C. An interaction term (rootstock × storage conditions) was significant in both years. Fruit from CA usually had the highest firmness, independently of the type of rootstock. Comparison the fruit firmness before and after storage revealed the fact, that overall storage period decreased 'Regina' fruit firmness for all rootstocks.

Table 3. Fruit quality of 'Regina' sweet cherry after 2 weeks of air and controlled atmosphere storage (2012 year)

		df[y]	Firmness (N)	SSC (%)	TA (mg 100 g^{-1})	SSC/TA	Fungal decay (%)
Roostock (A)	F12/1		18.4 a[x]	15.1 b	0.58 b	26.2 b	0.3 a
	Tabel-Edabriz		18.9 b	18.4 d	0.56 a	32.5 d	0.3 a
	Weiroot 10		20.2 b	14.0 a	0.59 b	24.0 a	0.3 a
	Damil		21.1 c	15.9 c	0.58 b	27.4 c	1.3 b
Storage conditions (B)	NA 8°C		17.1 a	16.6 b	0.56 a	29.9 c	1.3 c
	NA 2°C		19.8 b	15.5 a	0.57 a	27.2 b	0.2 b
	CA 2°C		22.0 c	15.4 a	0.60 b	25.6 a	0.0.a
Significance	A	3	–	–	–	–	–
	B	2	–	–	–	–	–
	A × B	6	–	–	–	–	–

[x] – within a column, values followed by the same letter are not significantly different
y – degrees of freedom

Soluble solids content in 'Regina' fruit after storage differed compared to the values at harvest (tabs 1, 2 and 3). In both seasons after storage SSC was significantly affected by rootstocks and storage regime (tabs 2 and 3). The highest content of SSC was always noted in fruits gathered from trees cultivated on Tabel-Edabriz, while the lowest values in fruit from trees cultivated on Weiroot 10 rootstock. Fruit stored in NA 8°C demonstrated the higher content of soluble solids than from CA 2°C and NA 2°C. The significant effect of interaction between rootstocks and storage conditions was proved in both seasons.

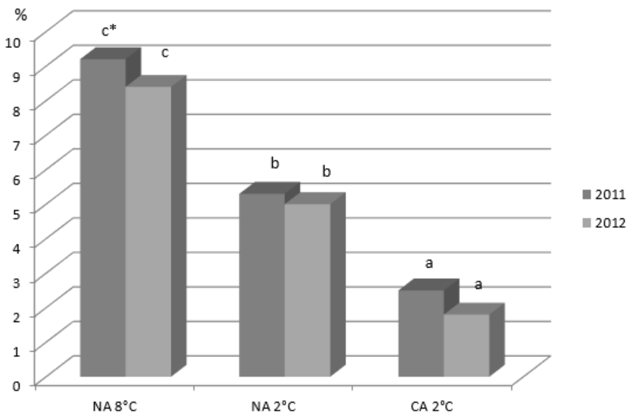

Fig. 1. Natural weight losses of 'Regina' sweet cherry fruit during storage (%)
* – mean values followed by the same letters are not significantly different at α = 0.05

The effect of rootstock on TA after harvest was demonstrated in the second season only (tab. 1). Comparison TA values before and after storage revealed the decreasing of acids content in fruit for all tested rootstocks (tabs 1, 2 and 3). Fruit harvested from trees grafted on Tabel-Edabriz contained significantly less acids compared to fruit from other rootstocks, similarly as it was revealed at harvest time, in 2012 year. The storage conditions affected significantly the acidity in both studied seasons. Fruit stored in control atmosphere was characterized always by higher acidity compared to fruit from normal atmosphere at 8°C. Significant effect of interaction between rootstock and storage condition on TA was noted in the second season.

Important factor influencing the acceptance of fruit by consumers is fruit taste, which is related to SSC/TA ratio. In the presented studies the ratio was significantly affected both by rootstocks and the storage conditions (tabs 1, 2 and 3). At harvest time the highest values of this index was achieved for fruit from trees cultivated on Tabel-Edabriz, 28.8–26.7 respectively in two seasons (tab. 1). Also after storage these fruits exhibited the highest values of SSC/TA ratio − 33.2 and 32.5 in two seasons, respectively (tabs 2 and 3). Interaction between type of the rootstock and storage conditions significantly affected that index.

As a result of dehydration of fruit and peduncle during cold storage the loss of fruit weight was noted (fig. 1).

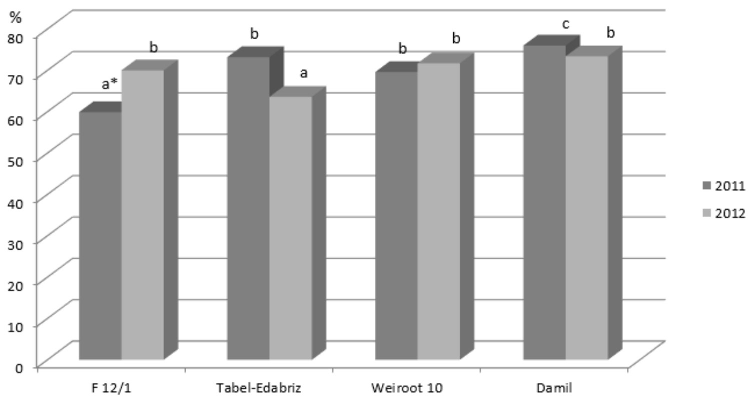

Fig. 2. Percentage of green peduncle of 'Regina' sweet cherry fruit affected by rootstocks
* – mean values followed by the same letters are not significantly different at α = 0.05

Sweet cherry fruit exhibits high susceptibility to fungal decay, mainly to brown rot (*Monilia* spp.), which is responsible for postharvest losses of fruits. Percentage of fruits with fungal decay symptoms varied in two studied seasons (tabs 2 and 3). Both type of rootstock and storage conditions affected the infection of fruits. In the first season the lowest percent of infected fruits was noted for Damil rootstock (tab. 2). Low temperature and controlled atmosphere significantly limited the percent of infected fruits. It is clear visible that the season had the effect on the fungal diseases appearance during fruits storage.

In the presented studies the symptoms of the weight loss were observed on fruit (wrinkling and pitting) and on the peduncles (wilting and loss of turgor). These symptoms were significantly affected only by storage conditions in both seasons (fig. 1). Storage at CA 2°C caused the least loss of fruit weight. Nearly 10% loss of fruit weight at NA 8°C negatively affected the fruit quality after storage.

Maintenance of green colour of sweet cherry fruit peduncle after storage is very important feature, which influences the fruit quality and consumer acceptability.

The rootstocks significantly affected the percentage of green peduncles in two seasons (fig. 2). In the first season better maintenance of the green colour was observed for dwarfing rootstocks, whereas in the second season such regularity was not observed.

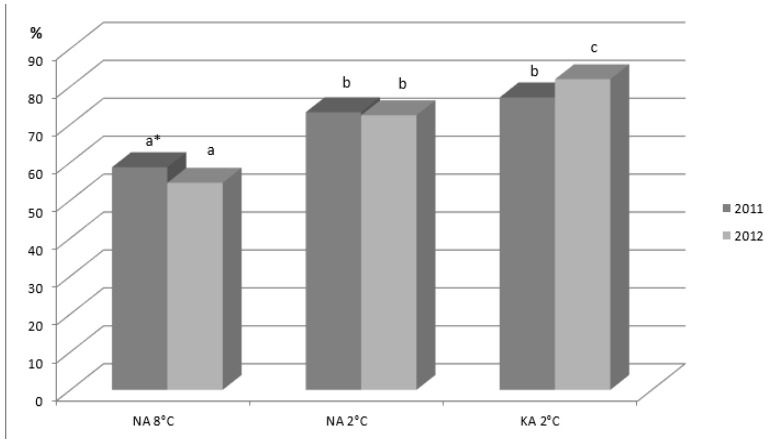

Fig. 3. Percentage of green peduncles of 'Regina' sweet cherry fruit affected by storage conditions
* – mean values followed by the same letters are not significantly different at α = 0.05

The effect of storage conditions on inhibition of the peduncles browning was more pronounced (fig. 3). The peduncles from NA 2°C and CA 2°C significantly better maintained green colour.

DISCUSSION

Sweet cherry, as non-climacteric fruit is harvested at consumer maturity. This fact is associated with proper content of soluble solids, organic acids and ratio between those two values. The research carried out confirms the fact, that the quality of sweet cherry fruit at harvest time largely affects their quality after storage. Also it is known, that rootstocks on which the trees are grown, influence many fruit features, both external (size) and internal ingredients. In the earlier studies (years 2008–2009) performed on the same younger trees of 'Regina' high content of SSC and SSC/TA ratio for fruit from trees cultivated on Tabel-Edabriz rootstock was found [Dziedzic 2012]. Other authors [Lugli and Sansavini 2008, Rozpara 2008] proved SSC in 'Regina' fruit at level 18.7–20.3%, depending on the rootstock. Many authors pointed, that the strong relationship between rootstock and grafted cultivar influence the ingredient content in the fruit. Kankaya et al. [2008] exhibited, that rootstock GiSelA-5 often increases SSC content in sweet cherry fruit. Gonçalves et al. [2005] observed distinct effect of dwarfing and invigorating rootstocks in 'Van' cherries. Fruit had the highest firmness and soluble sugar concentrations when grafted on dwarfing rootstocks, which implies a high resistance to post-harvest damage and high consumer acceptability. The same authors reported that fruits of 'Burlat' and 'Summit' grafted on invigorating rootstocks had the highest soluble sugar concentrations, whereas 'Van' fruits grafted on dwarfing rootstocks. Usenik et al. [2010] have found similar effect of rootstocks on firmness and soluble solids content for 'Lapins' sweet cherry growing on several rootstocks. In presented results SSC in fruit mostly achieved the level of 14–17%, what is in agreement with the suggestions of Kader [1999].

In the discussed study, the significant effect of rootstock on fruit firmness after storage was proved only in the second season, although similar relationship was observed in the first season as well. Vigorous F12/1 rootstock increased the fruit firmness. Similarly results obtained Cavalheiro et al. [2005], who reported about significantly lower firmness of 'Summit' sweet cherry fruit from trees grafted on vigorous *P. avium* rootstock than from trees growing on Tabel-Edabriz rootstock after storage. The finding, that high CO_2 concentration and low temperature promote the higher fruit firmness is exhibited by some researches, for 'Napoleon' [Jiang et al. 2002] and 'Vanda' and 'Van' fruits [Goliáš et al. 2006]. Temperature during storage also may affect the fruit firmness, what was evidence in the presented study, at 2°C and 8°C in NA conditions. Chen et al. [1981] confirmed this observation; they found increasing in 'Bing' fruit firmness after 35-day storage, at lowering temperature from 5.6°C to 1.1°C.

The higher content of SSC noted in the fruit after storage compared to initial values after harvest can be assign to fruit and stem dehydration during the storage. This observation is confirmed by finding of Kappel et al. [2002] and Cavalheiro et al. [2005]. Also temperature affected sugar concentration in fruit. Lower temperature (2°C) of storage resulted in lower SSC due to lower mass loss. We observed that after storage, in 9 of 24 treatments (rootstock/storage regime) SSC in fruit 'Regina' reached at least 16%, what is the acceptable level for the most consumers. The presented studies showed that the rootstock affected sugar concentration in 'Regina' fruit. Similarly, Cavalheiro et al. [2005] have found that rootstock GiSelA – 5 decreased SSC in 'Summit' fruit after 42-day storage compared to other rootstocks.

Organic acids content is also important factor, influencing sweet cherry fruit quality. Similarly, as in presented studies, Cavalheiro et al. [2005] have revealed lower TA content in 'Summit' fruit from dwarfing rootstocks compared to more vigorous rootstocks. According to other authors TA content was lowering with the storage time (10–60 days), and was significantly higher in CA-stored fruit than in modified atmosphere [Tian et al. 2004]. Also, after 15 days of storage in normal atmosphere at 1°C and 95% RH decreasing of TA was observed [Esti et al. 2002]. According to different studies the effects of varying oxygen levels on acid retention are ambiguous. Some of them [Meheriuk et al. 1995, 1997] did not notice any effect of atmospheric composition on acid retention in cherries; others studies have hinted that low oxygen levels are needed to reduce acid loss [Singh et al. 1970, Chen et al. 1981]. Acids content is associated with pH values, what in turn affects the colour of sweet cherry fruit. As pH increases, the color of anthocyanins moves to the non-spectral purple and approaches a progressive loss of color [Gonçalves et al. 2007]. Bernalte et al. [2003] proved that the changes in TA were observed after delaying the cooling time of cherries. This finding is important because in usual commercial practice, cherries are not refrigerated until around 5 h after harvest. Moreover, organic acids influence not only the fruit taste, but affect the production of volatile [Vavoura et al. 2015], what in turn is acceptable by consumers.

SSC/TA ratio is predominant parameter for consumer acceptance together with the absence of stem browning [Crisosto et al. 2003]. Consumer acceptability increases with high SCC and TA levels [Crisosto et al. 2003, Kalyoncu et al. 2009]. In the most treatments the ratio exceeded the value of 30, what is in accordance with the statement, that acceptable ratio between sweetness and sourness for sweet cherry should be of 20+ [Kader 1999]. Vavoura et al. [2015] have found an extremely high ratio at the level of 51.8–75.0 for Canada Giant, Lapins, Ferrovia and Skeena cultivars, as a result of very low acidity content in this fruit.

Loss of fruit weight is one of the reasons of fruit quality degradation after storage. Water loss takes place through the fruit skin and the peduncle. Sweet cherry peduncles exhibit up to eightfold higher water losses, than the fruit do [Sekse 1988, Linke et al. 2010]. Weight loss in cherries is higher than in other commodities not only due to the low skin diffusion resistance, but also to a higher surface/volume ratio [Wani et al. 2014]. Many researchers obtained results similar to the discussed experiment for other sweet cherry cultivars, whereas the amount of weight losses was conditions of storage and season dependent [Rutkowski et al. 2000, Kappel et al. 2002, Szymczak et al. 2003, Goliaš et al. 2007]. According to Rutkowski et al. [2000] and Szymczak et al. [2003] the loss of 'Kordia' fruit weight in NA conditions irrespective of the temperature (-0.5°C or +5°C) achieved the level of 5–6%. Significant weight loss for 'Hedelfingen' and 'Lapins' sweet cherry in the control treatments (air storage, 3°C, 90% RH) over time (6 to 13%) was noted, whereas the modified atmosphere treatments showed minimal losses [Padilla-Zakour et al. 2004]. The fruit weight losses affect the shortening of sweet cherry shelf-life and deterioration of fruit quality [Serrano et al. 2005].

Sweet cherry has a very perishable flesh with thin skin, contains a great amount of water, and during the fruit ripening and harvest very often rains are observed. High relative humidity during storage that is necessary for decreasing evaporation from fruit and peduncle may enhance the fungal infection of fruit. In presented experiment at the case of lower oxygen concentration in controlled atmosphere conditions the beneficial effect on the reduction of fungal infection percentage was exhibited. Other studies confirmed above observation [Krupa and Tomala 2000, Wang and Vestrheim 2002, Tomala et al. 2003]. Krupa and Tomala [2000] and Tomala et al. [2003] reported that after six weeks of storage, CA conditions limited the percentage of 'Regina' fruits decay (less than 3%) compared to fruit from NA (23%). Similarly, Tian et al. [2004] showed the beneficial effect of CA conditions on low percent (1.6%) of fruits decay even after 60 days of storage.

Sweet cherry fruit loses water very quickly after harvest during storage and shelf-life. Loss of water, as abiotic stress, causes chlorosis, which results from chlorophyll breakdown and browning of the peduncles is observed finally [Heaton and Marangoni 1996, Hörtensteiner and Kräutler 2011]. This finding was conformed in the presented studies. For fruit stored in different storage conditions the clear relationship between loss of weight and maintenance of green peduncle color was noted. Fruit from NA 8°C exhibited the greatest loss of weight and the lowest percent of green peduncles. Among the studied rootstocks the differences in weight loss were very little and such relationship was not proved.

CONCLUSIONS

The investigated rootstocks significantly affected the fruit parameters (fruit firmness, SSC and TA content, SSC/TA ratio) at harvest depending on the season. After storage the effect of rootstocks was proved for SSC, SSC/TA ratio and percent of fungal decay in both years. Fruit from CA 2°C exhibited the best quality after two weeks of storage, due to maintain of high fruit firmness, proper soluble solids and organic acids content, low percent of weight losses and fungal diseases. The knowledge of the effects of rootstocks and storage regime on parameters of sweet cherry fruit is essential for the proper selection of storage conditions for the perishable sweet cherry fruit for short time storage.

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WPŁYW PODKŁADEK ORAZ WARUNKÓW PRZECHOWYWANIA NA JAKOŚĆ OWOCÓW CZEREŚNI ODMIANY REGINA

Streszczenie. Podkładka modyfikuje cechy owoców w czasie wzrostu i owocowania drzew w sadzie. Badania zostały podjęte w celu wykazania wpływu podkładki na jakość owoców czereśni odmiany 'Regina' przed okresem przechowywania i po tym okresie. Doświadczenia prowadzono w warunkach chłodni zwykłej w temp. 8°C i 2°C oraz warunkach kontrolowanej atmosfery (3% O2 + 5% CO_2). Owoce pobierano w latach 2011 i 2012 w stadium dojrzałości zbiorczej i przechowywano dwa tygodnie w chłodni. Bezpośrednio po zbiorze owoce były oceniane pod kątem jędrności, zawartości ekstraktu, kwasowości, a po przechowywaniu – pod względem jędrności, zawartości ekstraktu, kwasowości, ubytków masy, zmiany barwy szypułki oraz procentu gnijących owoców. Zarówno podkładki, jak i warunki przechowalnicze wpłynęły na większość badanych cech owoców. Wpływ podkładki był zróżnicowany i zależny od roku badań. Owoce z drzew uprawianych na podkładce Tabel-Edabriz wykazywały większą zawartość ekstraktu w obydwu latach badań. Owoce przechowywane w warunkach kontrolowanej atmosfery w temperaturze 2°C cechowały się większą jędrnością, wykazywały większą kwasowość oraz w najmniejszym procencie były porażane przez choroby. Natomiast owoce przechowywane w normalnej atmosferze i temperaturze 8°C cechowały się największą zawartością ekstraktu oraz największym stosunkiem ekstraktu do kwasowości. Przechowywanie owoców w warunkach kontrolowanej atmosfery powodowało najmniejsze ubytki wagi owoców.

Słowa kluczowe: kontrolowana atmosfera, jędrność, zawartość ekstraktu, kwasowość, gnicie owoców

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