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FIELD PERFORMANCE, FRUIT CHEMICAL COMPOSITION AND FIRMNESS UNDER COLD STORAGE AND SIMULATED "SHELF-LIFE" CONDITIONS OF THREE BLUE HONEYSUCKLE CULTIGENS (*Lonicera caerulea*)

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A B S T R A C T

Three cultigens of blue honeysuckle ('Wojtek', 'Czarna' and seedling "N") were compared with each other in a two-year experiment carried out in the climatic conditions of Western Pomerania, Poland. The greatest crops in 2006 and 2007 were obtained from 'Wojtek' cultivar (1118 g and 755 g per a bush, respectively), whereas the yields of 'Czarna' and "N" were significantly lower. The bushes of 'Czarna' gave the lowest windfall of fruit (8.55% at average for two years). This cultivar produced berries with the highest weight of 100 fruits (115 g) and the highest firmness (220 G·mm^{-1}). On the other hand, in each year of the experiment the fruit of "N" seedling had the highest dry weight (13.90%), soluble solids (11.85%) and vitamin C (85.30 mg·100 g^{-1}) contents.

During cold storage (temp. 2-3^{o}C, relative air humidity 96%) and in the simulated "shelf-life" conditions (temp. 20^{o}C, relative air humidity 75%), some changes in fruit weight and firmness were observed. However, immediate cooling of berries after harvest prolonged the time of their storage up to seven days. On the other hand, berries kept for eight hours in "shelf-life" conditions showed considerable loss of mass (10%) and significant lowering of firmness.

Key words: blue honeysuckle, yield, firmness, fruit chemical composition

INTRODUCTION

The gender *Lonicera* comprises approximately 200 species. The first report about the cultivation of blue honeysuckle (*Lonicera caerulea*) was published in 1894 (Plekhanova, 2000).

The majority of *Lonicera* species have inedible or even poisonous fruit. The plants bearing edible fruit belong to *Caerulea* Red. section. It comprises *Lonicera caerulea* var. *edulis* Reg., *L. caerulea* var. *tanganica* Max., *L. caerulea* var. *kamtschatica* Sevast. and *L. caerulea* var. *altaica* (Pall.) Sweet (Bieniek et al., 2005).

Both edible and inedible species are distributed throughout Northern hemisphere, mostly in the temperate regions. The blue honeysuckle is widely cultivated in Russia, China, and Japan, and has recently been introduced into the USA (Chaovanalikit et al., 2004). Throughout Europe, the climatic conditions are propitious for the cultivation of *Lonicera* bushes. The plants are frost-resistant and they do not get frozen even when the temperature drops below -40°C, whereas expanded flowers do not get injured down to -8°C. The Siberian types are said to be hardy even at -50°C (Bors, 2008). However, the best growth and fruit bearing are obtained from the plants grown in sunny regions where the fruit ripen several days before strawberries and raspberries (Marková, 2001; Hummer, 2006). When weather conditions are favorable, the fruit start ripening even in May (Arus and Kask, 2007). The bushes and fruit are rarely infested by pests or pathogens, thus the chemical control of honeysuckle is limited to the "as needed" occasions (Thompson, 2007).

Blue honeysuckle is also called honeyberry, sweetberry honeysuckle, edible honeysuckle and, in Japan, haskap or haskappu (Bors, 2008). The flesh of fruit is dark-purple, aromatic, juicy, sweet and sour, and their taste resembles that of bilberry (Kawecki, 1996). However, the taste of honeysuckle berries is frequently bitter, especially when the fruit is obtained from plants grown from seeds. The fruit are rich in minerals anthocyanins, phenolic compounds and possess high antioxidant capacity (Oszmiański et al., 1995; Thompson and Chaovanalikit, 2003; Jordheim et al., 2007; Skupień et al., 2007; Suzuki et al., 2007). The *Lonicera* berries are considered to be very healthy and have anti-inflammatory and anti-bacterial activities (Park et al., 2005; Jin et al., 2006). The growing interest in cultivation of honeysuckle has contributed to breeding new cultivars. Therefore, the research was undertaken on physical features (mass and firmness of the fruit) and chemical composition (dry matter, soluble solids, titratable acidity, ascorbic acid, and nitrate contents) of the new Polish honeysuckle cultivars.

MATERIAL AND METHODS

The experiment was carried out in the years 2005-2007 at the Experimental Station of Agricultural University of Szczecin at Rajkowo, North-Western Poland. Two Polish-bred cultivars of blue honeysuckle

'Czarna', 'Wojtek' and non-specified seedling "N" were tested. The bushes of 'Czarna' and 'Wojtek' were obtained from a nursery of Polish breeders. The seedlings of "N" were purchased as *L. caerulea* var. *kamtschatica* Sevast without any further specification. The genetic tests carried out at Agricultural University of Szczecin showed that the Polish-bred cultivars were phylogenetically different compared with the Russian ones.

Two year-old potted plants were planted in the spring of 2005 into well-drained brown soil at the spacing of 3 × 1 m. The soil (III quality class) was rich in nutrients. The randomized block experimental design was used with three replicates (four bushes per a plot).

The fruit were collected subsequently as they achieved the stage of full ripeness. To determine the total yield and fruit drop, in 2006 the berries of 'Wojtek' and the "N" seedling were harvested eight times, whereas in 2007 – seven times. The fruiting of the cultivars began in the middle of May. The fruit of 'Czarna' were collected in both years four times starting with the beginning of June.

The yield per bush was measured in grams (g), the fruit drop was expressed in percents (%), the mass of 100 fruits was determined in grams (g), and the firmness of 50 randomly selected berries from each replication was measured with the non-destructive computerized device FirmTech 2 (BioWorks, USA) directly after harvest (0) and after 0.5, 1, 2, 4, 8, 16, 24, 48, 72, 96, 120, 144, 168 h of storage in a cold room (temp. 2-3^{o}C, relative air humidity 96%) or in simulated "shelf-life" conditions (temp. 20^{o}C, relative air humidity 75%) (Grajkowski, 1995). The firmness and fruit mass measurements were conducted twice in 2006 and 2007.

Dry weight was determined by gravimetric method, soluble solids with Abbé refractometer, vitamin C content by iodometric method according to Samotus et al. (1982). Titratable acidity was determined by potentiometric method using pH-meter Orion 720 A, USA, and expressed as equivalents of citric acid.

The results obtained were subjected to statistical analysis using Statistica 7.1 (Statsoft, Poland). The analysis of variance in the form of two-year synthesis for fixed model was applied for yield and fruit chemical composition. The values were evaluated by the Duncan test and the differences at $p < 0.05$ were considered significant.

RESULTS AND DISCUSSION

In the first year of cultivation, only very low yield of berries was obtained (up to 55 g per a bush). In 2006 the yield of 'Wojtek' (1118 g per bush) was more than twice as bg as the yield of 'Czarna' and "N" (Tab. 1). However, in 2007 the yield of 'Wojtek' and 'Czarna' decreased (by 32 and 16%, respectively), whereas the yield of honeysuckle seedling "N" increased slightly (by 9%). Regarding the total three-year yield, the productivity of 'Wojtek' was significantly higher compared with the other cultigens. In the third

Table 1. Yield and quality traits of three blue honeysuckle fruit cultigens

Cultigen	Yield per bush [g]			Fruit drop [%]			Mean weight of 100 fruits [g]		
	Year								
	2006	2007	total	2006	2007	2007/2008 average	2006	2007	2007/2008 average
N	478a	519a	997a	24.2c	19.7c	21.95c	74.8a	82.6a	78.7a
Wojtek	1118b	755b	1873b	16.7b	15.6b	16.15b	86.0a	92.0b	89.0a
Czarna	547a	459a	1006a	6.9a	10.2a	8.55a	101.6b	128.4c	115.0b

Table 2. Chemical composition of three blue honeysuckle fruit cultigens

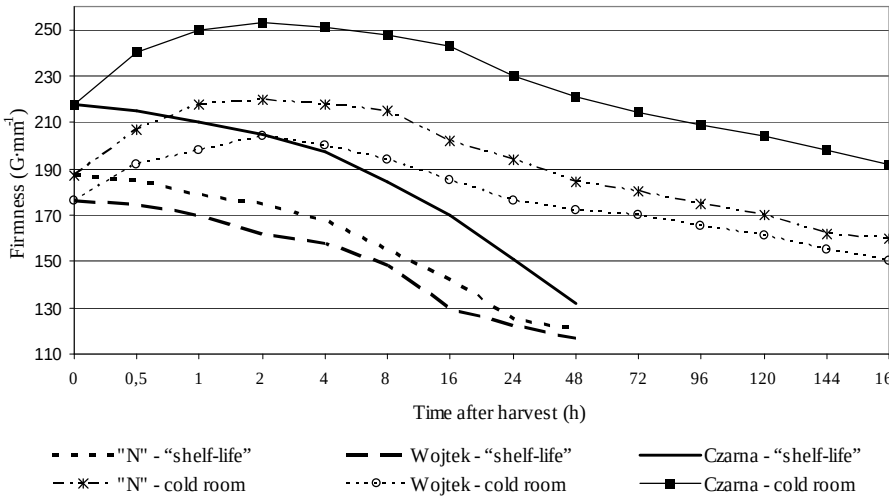
Cultigen	Soluble solids [%]			Dry weight [%]			Titratable acidity [g citric acid·100g $^{-1}$]			Vitamin C [mg·100g $^{-1}$]		
	Year											
	2006	2007	2006/ 2007 average	2006	2007	2006/ 2007 average	2006	2007	2006/ 2007 avrage	2006	2007	2006/ 2007 average
N	12.1b	11.6c	11.9b	13.96c	13.84c	13.90c	2.82a	3.61b	3.22b	72.6b	98.0b	85.3b
Wojtek	10.0a	11.0b	10.5a	12.62b	12.97b	12.80b	3.52b	3.43b	3.48b	69.9b	83.1b	76.5b
Czarna	9.8a	10.4a	10.1a	11.63a	12.01a	11.82a	2.99a	2.48a	2.74a	40.5a	65.5a	53.0a

year of the experiment the yield ranged from 755 g ('Wojtek') to 459 g ('Czarna'). According to Kawecki (1996) five-year-old honeysuckles yield 1000 g per bush, whereas Golis (2007) reports 2300 g for five-year-old bushes of 'Wojtek'.

The drop of ripe fruit is a serious problem in the cultivation of *Lonicera cearulea*. In the experiment the fruit drop ranged from 24.2% ("N"in 2006) to 6.9% ('Czarna' in 2006) (Tab. 1). Among the three cultigens tested the least tendency for fruit-shed in each year was observed in 'Czarna', while the highest one was observed in the "N" seedling.

The berries of 'Czarna' have significantly higher weight of 100 fruits (101.6 g in 2006 and 128.4 g in 2007) in comparison with that of 'Wojtek' and the "N" seedling (Tab. 1). The two-year mean fruit weight ranged from 0.8 g for "N" seedling to 1.15 g for 'Czarna'. Hummer (2006) reports that the weight of one fruit of Russian honeysuckle cultivars grown in Oregon, USA varied from 1 to 2 g. Similarly, Plekhanova (l995) reports that the fruit can weight up to 2.0 g and be 3-4 cm long.

The dry matter content measured in the honeysuckle fruit ranged from 11.63% ('Czarna' in 2006) to 13.96% ("N" seedling) (Tab. 2). Noteworthy, the dry matter content was a stable feature for each cultigen in both years of the experiment (± 0.9-2.8%).



The temperature of fruit just after harvest (0 h) was 18-24°C

Figure 1. The changes in firmness of three honeysuckle fruit cultigens during the storage (the mean of 2006-2007)

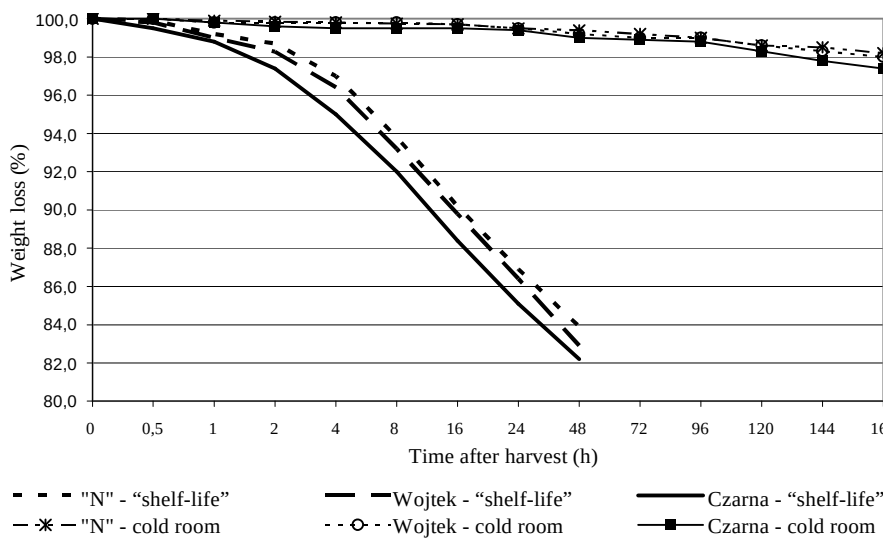


Figure 2. The loss of mass of three blue honeysuckle fruit cultigens during the storage (the mean of 2006-2007)

Regarding the two-year mean values, the fruit of "N" seeling had the highest dry weight content, whereas 'Czarna' the lowest. Kamzolova et al. (2006) observed 9.1-12.6% dry matter content for 15 cultivars grown in Belarus.

Parallel to the dry matter content, the total soluble solids content was also quite a stable feature in the two years of the experiment (± 4-10%). Significantly higher mean amount of soluble solids was observed in "N" berries (11.85%) compared to that of 'Wojtek' (10.53%) and 'Czarna' (10.09%) (Tab. 2). The soluble solids content observed for those cultivars was similar to that of 'Zielona' – 10.17% (Skupień et al., 2007).

The honeysuckle fruit was found rich in vitamin C. The content of ascorbic acid ranged from 40.48 mg·100 g^{-1} in 'Czarna' in 2006 to 98.00 mg·100 g^{-1} in "N" fruit in 2007 (Tab. 2). The higher amounts of vitamin C for all the cultivars were observed in 2007. On average, 'Czarna' berries had significantly less vitamin C compared with the other cultivars. Skupień et al. (2007) determined 42.68 mg/100 g vitamin C in the berries of 'honeysuckle 'Zielona'. Kamzolova et al. (2006) found that vitamin C content in honeysuckle cultivars grown in Belarus ranged from 28 to 48 mg/100 g. Plekhanova and Streltsyna (1993, 1998) also report high vitamin C content, ranging from 50 to 70 mg·100 g^{-1} on a fresh weight basis.

The fruit of honeysuckle is rich in carboxylic acids; 1.79-3.24 g·100 g^{-1} (Kamzolova et al., 2006). Total acid content observed in the experiment ranged from 2.48 g·100 g^{-1} ('Czarna' fruit in 2007) to 3.61 g·100 g^{-1} ("N" berries in 2007) (Tab. 2). In both years of the experiment 'Czarna' fruit showed a significantly lower acidity compared with 'Wojtek' and "N".

The measurements of firmness were done in the fruit right after the harvest (0 h, 18-24°C) and in the fruit stored in the cold storage (2-3°C, 96% RH), and in simulated "shelf-life" conditions (20°C, 75% RH). Cooling of the fruit after the harvest initially increased its firmness in comparison with the berries kept in the "shelf life" conditions (Fig. 1). Thus the highest firmness was observed in the cooled fruits stored for two hours. Furthermore, a consecutive decrease of firmness both for the fruit cooled and kept in the "shelf-life" conditions was observed. Regarding both methods of storage, 'Czarna' berries showed the best ability of preserving firmness, whereas the weakest one was found for 'Wojtek'. After 48 h, the berries of all cultivars lost above 40% of their initial firmness. The berries were stored in the cold storage for seven days. In these conditions the loss of firmness accounted to several percent only but the first signs of storage diseases appeared. It was mainly due to the very limited chemical plant protection applied during their vegetation. Additionally, the loss of bloom and shine on fruit skin were observed.

According to Harvey (1982), the loss of weight during the strawberry shipment should not exceed 10%. In our study, the mass of fruit stored in

the cold storage for 168 h decreased from 1.8% ("N") to 2.6% ('Czarna') (Fig. 2). As for fruit kept in the "shelf-life" conditions, a 10% decline of weight was noticed after ~12 h for 'Czarna' and after ~20 h for 'Wojtek' and "N". The quality of "N" berries was slightly better compared with that of the other cultivars. After 48 h the berries stored in the "shelf-life" conditions totally lost their consumption value due to softening of tissues and mold development.

CONCLUSIONS

1. In the experiment, the blue honeysuckle bushes began to yield in the first year of planting. In 2006 and 2007 the highest crop was obtained from the bushes of 'Wojtek'.
2. The bushes of 'Czarna' in both years of experiment showed the lowest fruit drop and the highest mass of 100 fruits.
3. On average (for two years), the fruit of *L. caerulea* seeling ("N") had the highest content of dry matter, soluble solids and vitamin C, whereas the berries of 'Wojtek' contained the greatest amount of total acids.
4. The conditions of storage tested in the experiment influenced the quality of fruit. For the fruit kept in simulated "shelf-life" conditions (20°C, 75% RH), a considerable loss of firmness and weight was observed. On the other hand, the storage of berries at 2-3°C and 96% relative air humidity allowed to maintain fruit mass and firmness over a period of seven days.

REFERENCES

Arus L., Kask K. 2007. Edible honeysuckle (*Lonicera caerulea* var. *edulis*) – underutilized berry crop in Estonia. NJF REPORT 3(1): 33-36.

Bieniek A., Kawecki Z., Łojko R., Stanys V. 2005. *Lonicera* – suchodrzew i wiciokrzew. In: Z. Kawecki (ed.), Owocodajne drzewa i krzewy chłodniejszych stref klimatycznych. Wydaw. Uniwersytetu Warmińsko-Mazurskiego w Olsztynie, pp. 80-86.

Chaovanalikit A., Thompson M.M., Wrolstad R.E. 2004. Characte-rization and quantification of anthocyanins and polyphenolics in blue honeysuckle (*Lonicera caerulea* L.). J. AGRIC. FOOD CHEM. 52: 848-852.

Golis T. 2007. Jagoda kamczacka – cenna roślina do uprawy towarowej. SAD NOW. 10: 25-27.

Grajkowski J. 1995. Einfluss verschiedener CA/ULO-Lagerungsvarianten auf 'Cox Orange', 'Rote Boskoop' und 'Elstar' in Abhängigkeit von Erntetermin und Behangstärke. Ph.D. thesis. Dissertation, Humboldt University, Berlin, 161 p.

Harvey J.M. 1982. CO_2 atmospheres for truck shipments of strawberries. ORE. STATE UNIV. SCHOOL OF AGRIC. SYMP. SER. 1: 359-365.

Hummer K.E. 2006. Blue honeysuckle: a new berry crop for North America. J. AM. POMOL. SOC. 60: 3-8.

Jin X.H., Ohgami K., Shiratori K., Suzui Y., Koyama Y., Yoshida k., Ilieva T., Tanaka T., Onoe K., Ohno S. 2006. Effects of blue honeysuckle (*Lonicera caerulea* L.) extract on lipopolysaccharide-induced inflammation *in vitro* and *in vivo*. EXP. EYE RES. 82(5): 860-867.

Jordheim M., Giske N.H., Andersen Ø.M. 2007. Anthocyanins in *Caprifoliaceae*.

BIOCHEMICAL SYSTEMATICS AND ECOLOGY 35(3): 153-159.

Kamzolova O.I., Pigul M.L., Lipskaia S.L. 2006. Biochimiczeskaia ocenka sortov żimiloscti siniei v usloviach Belarusi. PLODOVODSTVO 18(1): 110-114.

Kawecki Z. 1996. Nowe rośliny w uprawie sadowniczej. In: Nowe rośliny i technologie w ogrodnictwie. II Ogólnopol. Symp. w Roku Jubileuszu 40-Lecia Wydziału Ogrodniczego Akademii Rolniczej w Poznaniu. Poznań, 17-19 września 1996, pp. 22-31.

Bors B. 2008. Blue honeysuckle. Available at: http://www.usask.ca/agriculture/plantsci/dom_fruit/articles/blue_honeysuckle2.pdf.

Marková R. 2001. Study of vegetative, growing and economic character of genus *Lonicera* subsect. *caerulea* REHD. Proc. 9th Int. Conf. Horti. September 3th–6th 2001, Lednice, Czech Republic 1, pp. 130-135.

Oszmiański J., Souquet J.M., Moutounet M. 1995. Antocyjany owoców borówki kamczackiej. (Anthocyanins of honeysuckle kamtschatica fruit). ZESZ. NAUK. AKAD. ROL. WROC., TECHNOL. ŻYWN. VIII (273): 67-72.

Park E., Kum S., Wang C., Park S.Y., Kim B.S., Schuller-Lewis G. 2005. Anti-inflamatory activity of herbal medicines: inhibition of nitric oxide production and tumor necrosis factor-alpha secretion in an activated macrophage-like cell line. AM. J. CHIN. MED. 33(3): 415-424.

Plekhanova M.N., Streltsyna S.A. l993. Chimičeskii sostav plodov vida *Lonicera* podsekc. *Caeruleae* (*Caprifoliacea*). RASTITELNYE RESURSY 29(2): 16-25.

Plekhanova M.N., Streltsyna S.A. 1998. Fruit chemical composition of Lonicera subscect. caerulea (Caprifoliaceae) species. ESTONION AGR. UNIV. FOREST RES. INST. FORESTRY STUDIES. XXX: 143-147.

Plekhanova M.N. l995. Blue honeysuckle: a new berry crop in Russia. Balsgaard Ann. Rep. for l992-1994, Dept. Hort. Plant Breeding, Swedish University of Agricultural Sciences, Balsgaard, Sweden, pp. 180-182.

Plekhanova M.N. 2000. Blue Honeysuckle (*Lonicera caerulea* L.) – a new commercial berry crop for temperate climate: genetic resources and breeding. ACTA HORT. 538: 159-164.

Samotus B., Leja M., Ścigalski A. 1982. Porównanie czterech metod oznaczania kwasu askorbinowego w owocach i warzywach. (E comparison of four methods of determination of ascorbic acid in fruits and vegetables). ACTA AGRARIA ET SILV., SER. AGRARIA XXI: 105-121.

Skupień K., Oszmiański J., Ochmian I., Grajkowski J. 2007. Characterization of selected physico-chemical features of blue honeysuckle fruit cultivar 'Zielona'. POLISH J. NAT. SCI. (Suppl.) 4: 101-107.

Suzuki T., Uenohata M., Oosawa K. 2007. Polyploidy breeding of Blue honeysuckle and Black chokeberry by utilizing in vitro-cultures treated with colchicine. ACTA HORT. 760: 389-396.

Thompson M.M., Chaovanalikit A. 2003. Preliminary observations on adaptation and nutraceutical values of Blue Honeysuckle (*Lonicera Caerulea*) in Oregon, USA. ACTA HORT. 626: 65-72.

Thompson M.M. 2007. Haskap arrives in North America. Home Orchard Society, Oregon, USA. Available at: http://www.homeorchardsociety.org/article/42.

PLONOWANIE, SKŁAD CHEMICZNY ORAZ JĘDRNOŚĆ OWOCÓW W WARUNKACH PRZECHOWYWANIA "SHELF-LIFE" ORAZ CHŁODNICZYCH TRZECH ODMIAN JAGODY KAMCZACKIEJ (*Lonicera caerulea*)

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S T R E S Z C Z E N I E

W dwuletnim doświadczeniu w warunkach klimatycznych Pomorza Zachodniego porównywano trzy genotypy jagody kamczackiej 'Wojtek', 'Czarna' oraz nieokreślony genotyp ("N"). Największy plon w 2006 i 2007 roku dała odmiana 'Wojtek' (odpowiednio 1118 i 755 g), natomiast istotnie niższe plony uzyskano z odmiany 'Czarna' i genotypu "N". Najmniej owoców opadało z krzewów odmiany 'Czarna' (średnio z dwóch lat 8,55%). Odmiana ta miała jagody o największej masie (100 g owoców ważyło średnio 115 g) i o najwyższej jędrności (średnio 220 $G \cdot mm^{-1}$). W każdym roku doświadczenia jagody "N" wykazywały największą zawartość suchej masy (średnio 13,9%), ekstraktu (średnio 11,85%) i witaminy C (średnio 85,30 $mg \cdot 100\ g^{-1}$).

Podczas przechowywania zarówno w warunkach "shelf-life" (temp. 20°C), jak i chłodniczych (temp. 2-3°C, wilgotność względna 96%) obserwowano zmiany masy oraz jędrności owoców. Natychmiastowe schłodzenie owoców po zbiorze wydłużyło czas ich przechowywania aż do 7 dni. Natomiast owoce przechowywane w warunkach "shelf-life" po 8 godzinach wykazywały znaczący spadek masy (o 10%) oraz istotne obniżenie jędrności.

Słowa kluczowe: jagoda kamczacka, plon, jędrność, skład chemiczny owoców