Assessment of Selected Physical Properties of Fresh and Stored Large Cranberry Fruit

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Summary. The study has identified selected mechanical properties of fresh and stored fruit of large cranberry. The analyses focused on the changes in the values of peel and flesh puncture strength in the selected cranberry varieties depending on water content and storage duration. Measurements were also performed to examine deformations and energy needed to cut through the fruit peel and flesh. The value of breaking stress was calculated. The findings show a decrease in the relevant parameters during storage of fruit obtained from the examined varieties of large cranberry. Mean water contents in the fruit of the relevant varieties were in the range of 86.4-89.1%. There was a notable decrease in the mean value of peel and flesh puncture strength in the fruit of the relevant varieties of large cranberry. The mean value of peel and flesh puncture strength in the fresh fruit of cranberry was 6.1 N, and after 40 days in storage the value decreased by 2.3 N.

Key words: large cranberry, mechanical properties, peel and flesh puncture strength, water contents.

INTRODUCTION

Large cranberry (*Vaccinium macrocarpon Aiton*) is a perennial plant representing the heath family. This is an evergreen dwarf shrub quite commonly growing in bogs, and bearing fruit with colour ranging from pink to dark purple, and with a diameter of approx. 20 mm, depending on the variety [3]. It is mainly cultivated in acidic soils of north-eastern regions of the USA and in Canada [12, 16].

At present the two most common varieties are: American and swamp cranberry (*Vaccinum oxycoccus*), the latter growing in Europe. Poland is also home to a third variety, considerably less common, and known as small-fruit or small-leaf cranberry (*Oxycoccus microcarpus, syn. Vaccinium microcarpon*) [3].

The large cranberry specifically requires humus-type and moist substrate, as well as an acidic pH (from 3.2 to 4.5). Cranberry is a photophilic plant. Of extreme importance in cranberry cultivation is the use of sand cover, to reduce excessive acidity, retain high moisture of the soil, and control pest and fungi growth, and to promote the rooting of rhizomes [11, 16].

Irrigation is of particular importance during the first year of commercial cultivation of cranberry, due to the poorly developed roots system. In the natural environment we can encounter the large cranberry growing in relatively poor soils, yet its commercial cultivation requires additional irrigation and fertilization, the latter preferably with the use of ammonium sulphate, distributed in early spring, and towards the end of June when fruit start forming. Other important treatments applied in cranberry cultivation include trimming of excessively growing shoots during early spring. Excessive number of shoots leads to a decrease in the yield and to poor colouration [2, 7, 8, 9, 10, 15].

Researchers were inspired to investigate biological properties of cranberry mainly by folk medicine and the positive effects of using cranberry fruit and juice. For years it had been used with success by those with problems related to urinary tract and kidneys. Its antimicrobial effects were confirmed during *in vitro* studies with the use of Gram-positive bacteria: *Enterococcusfaecalis* and *Staphylococcus ureus*, as well as Gram-negative bacteria: *Escherichia coli*, *Pseudomonasaeruginosa*, *Salmonella enteritidis*, *Proteusmirabilis* and *Klebsiellapneumoniae*. Concentrated juice, diluted at 1:1 ratio, significantly inhibits the growth of the six examined strains of bacteria. Cranberry is also known for its antimycotic properties; a study investigated the activity of juice with pH of 5.6 related to nine fungal strains. Growth was inhibited in 7 out of 8 dermatophyte strains, including: *Microsporumcanis, Microsporumaudouini*, *Trichophytonmentagrophytes*, *Epidermophytonfloccosum* and *Microsporumgypseum* [1, 14, 15, 19, 20]. Equally important group of elements contained in cranberry fruit and known for their health promoting effects are polyphenols. Oszmiański et al. examined cranberry extract and identified the contents of approx. 22 polyphenolic compounds [17]. These include phenolic acids, flavonoids, anthocyanins, proanthocyanidins, and stilbenes [21].

Manual harvesting of berries is time consuming, and due to this many plantation owners look for a cheaper method of collecting fruit. Today, highly efficient fruit harvesting machines are becoming more and more common. During the harvesting process there is a high risk of mechanical damage as a result of which the quality of raw fruit is impaired or indeed a given batch of the raw material may even be unsuitable for processing. Due to this, in order to prevent losses, growers increasingly often carefully examine the conditions of transport, handling and storing the produce, to eliminate any hazards [18].

The methods applied during the delivery of raw cranberries to processing plants also affect water contents, as well as texture, firmness and quality of the final product. Likewise, water depletion and mechanical damage may be of importance during cranberry processing. Raw material may be unfit for processing not only because it has been crushed or bruised but also due to internal damage, which is hard to detect.

Data available in the literature present a considerable range of potential applications of cranberry in various sectors of industry and describe research methods making it possible to isolate specific chemical components. Yet, there are no comprehensive studies focusing on selected mechanical properties of cranberries and reporting the methods used for examining these berries [4, 13]. Cranberries of the selected varieties may be treated as spherical fruit and examined with the use of methodology proposed for strength measurement in such spherical fruit as tomatoes, onion, Brussels sprout, which were investigated for their selected mechanical properties [5].

The laboratory examinations were designed to determine the influence of the contents of water and dry matter on the selected mechanical properties of fresh and stored fruits of large cranberry, and to assess peel and flesh of fresh berries in terms of their resistance to mechanical damage resulting from puncture test with the use of punch probe with a diameter of 2 mm.

MATERIAL AND METHOD

The research material consisted of fruit of large cranberry obtained from a farm specializing in its production. The samples were cleaned and transferred, on the same day, to the location of the laboratory examinations, where they were placed in a cold storage. The examined varieties included: Red Star, Ben Lear, Franklin, Pilgrim, Marco Howes and Stevens. On the next day the selected mechanical properties were measured in the fresh berries. A punch probe with a diameter of 2 mm was applied to test peel and flesh of the fruit of the examined cranberry varieties. This measurement was repeated during storage: on the 14th, 25th and 40th day. The samples of each variety of berries were kept in defined temperature, i.e. at 20˚C, 10˚C and 4˚C.

Water contents were measured in raw fruit of the specific large cranberry varieties. The process was repeated on specified days throughout the duration of the study. Water contents in the fresh berries were determined using moisture balance at the temperature of 105°C. The measurements of water contents were carried out in randomly selected berries of the specific varieties.

The mechanical properties visible in a puncture process, were measured with the use of Zwick/ Roell testing machine applying a punch probe with a diameter of φ- 2 mm.

The puncture test examining peel and flesh of the cranberry varieties was carried out with the use of whole fruit, in 8 repetitions for each of the examined varieties, on 4 days of measurements carried out in fresh fruit and during the storage: on the 14th, 25th and 40th day. After each series of measurements a print-out was made to record the mean values of peel and flesh puncture strength, deformation and puncture energy; the value of breaking stress was also calculated. The obtained results were analysed with the use of Statistica 10 software. Normality of distribution for the investigated variables was examined with Shapiro-Wilk test, with confidence interval at α=0.05. After the test results were analysed and homogeneity of variances was verified, further analyses were carried out using one-way ANOVA. Statistical analyses results were shown in graphs in the form of letters of the alphabet.

RESULTS AND DISCUSSION

WATER CONTENT

Water contents in the samples were computed based on the formula:

$$W = \frac{(m_1 - m_2)}{m_1} \times 100 \, ,$$

where:
W – water content [%],
m_1 – mass of fresh samples [g],
m_2 – mass of dry samples [g].

Mean water contents in the fresh fruit of the relevant large cranberry varieties were in the range of 86.4 – 89.1%. Berries of the specific varieties differed only slightly in terms of water contents. No significant differences related to water contents were found between the fruit of the specific cranberry varieties. Figure 1 shows mean water contents in the fresh fruit of the relevant large cranberry varieties.

Berries stored at 20°C were found with the lowest water content – 86.4% – Franklin variety on the first day in storage; on the other hand the highest water content of 89.6% was recorded in Ben Lear berries, on the 14th day in storage.

The second measurement of water contents in the cranberries was carried out for the fruit stored at 10°C. At this temperature the lowest water content was observed in Ben Lear berries, on the 40th day of the study. The value was 86.1%. The highest water content of 90.2% was observed on the 40th day of the study in Red Star berries stored at

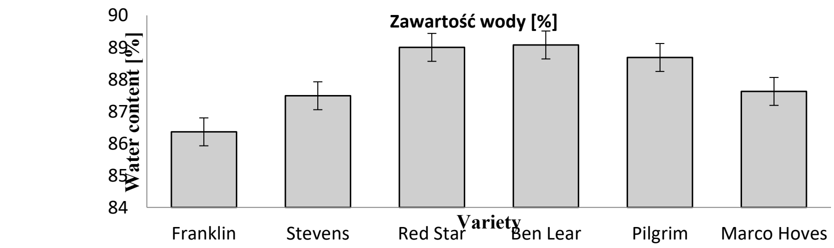

Fig. 1. Water contents [%] in the fresh fruit of large cranberry varieties

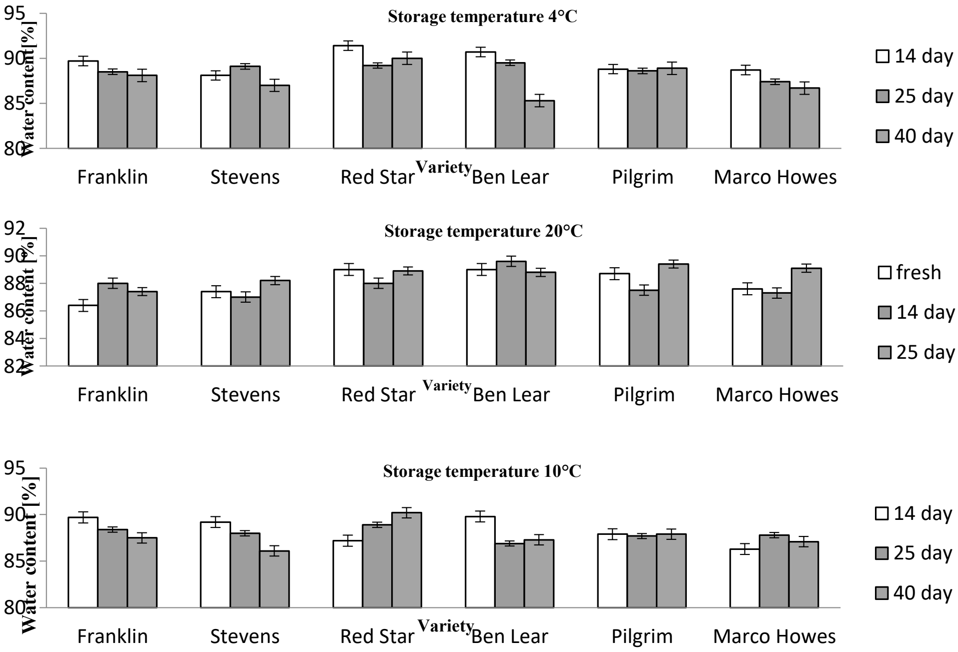

Fig. 2. Mean water contents in the fruit of the relevant large cranberry varieties, relative to the storage temperature

4°C. The lowest water content on the 40th day of the study was recorded in Ben Lear berries – 85.3%, and the highest value of the examined parameter was observed in Red Star variety on the date of the first measurement; the value amounted to 91.4%.

PEEL AND FLESH PUNCTURE STRENGTH

The results showing peel and flesh puncture strength in the fruit of the examined large cranberry varieties measured with the use of punch probe with a diameter of 2 mm, as well as the statistical analyses are presented in Figures 3-5.

Storage of cranberries at the temperature 20°C was associated with a decrease in peel and flesh puncture strength. Franklin and Stevens were found with the greatest decrease of 0.9 N between the first and the last measurement. At the temperature of 10°C the values of puncture strength decreased by 0.5 N in comparison to the highest value observed at the temperature of 20°C. Peel and flesh puncture strength decreased with longer duration of storage. The largest difference amounting to 1 N was recorded for Stevens variety. The lowest value of puncture strength observed in Red Star berries amounted to 4.9 N. During the storage of the berries at 4°C the decrease in peel and flesh puncture strength occurred most rapidly. The most significant difference was observed in Marco Howes variety – 2.3 N. In the conditions of cooling on the 40th day of measurement the value of the examined parameter was in the range from 5.4 to 3.3 N.

Figure 6 shows the trend line of the mean values of distraction stress to cut through the peel and flesh during storage of fruit of large cranberry, regardless of the storage temperature. The course of the trend line is described by the 2nd degree function $y=ax^2+bx+c$. The values of the coefficient of determination for the trend lines assigned to the values of the work are high and range from $R^2=0.97$ to $R^2=0.99$.

CONCLUSIONS

1. Mean water contents in the fruit of the relevant cranberry cultivars varied only slightly, and ranged from 86.4% to 89.1%.
2. Duration of storage did not significantly affect water contents in the cranberries; the difference between the fresh berries and the fruit stored for 40 days amounted to 4%.
3. Mean value of peel and flesh puncture strength F [N] in the fresh fruit of the relevant cranberry varieties stored for 14, 25 and 40 days was found to decrease, and the difference amounted to 2.3 N.
4. Mean values of distraction stress δ[MPa] needed to cut through the peel and flesh of the cranberries were varied;

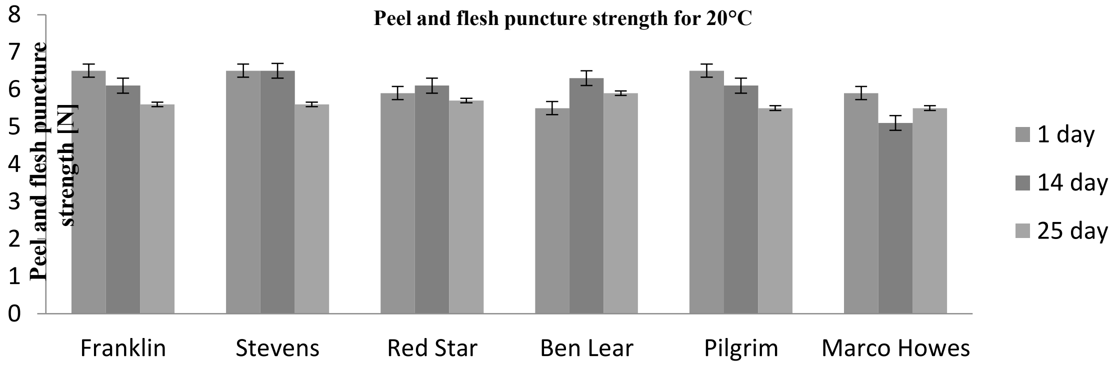

Fig. 3. Mean value of peel and flesh puncture strength in the fresh fruit of the relevant large cranberry varieties stored at 20°C

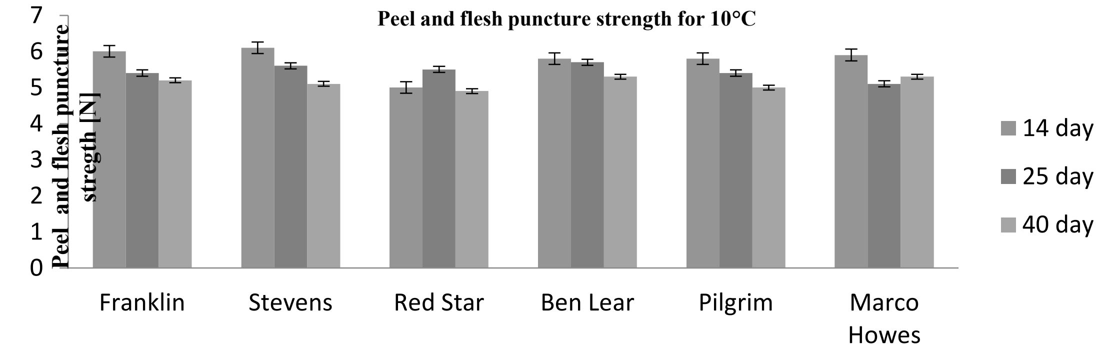

Fig. 4. Mean value of peel and flesh puncture strength in the fresh fruit of the relevant large cranberry varieties stored at 10°C

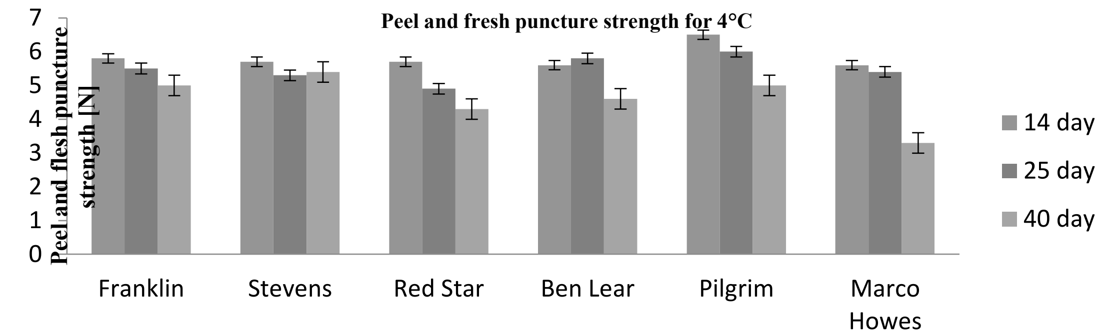

Fig. 5. Mean value of peel and flesh puncture strength in the fresh fruit of the relevant large cranberry varieties stored at 4°C

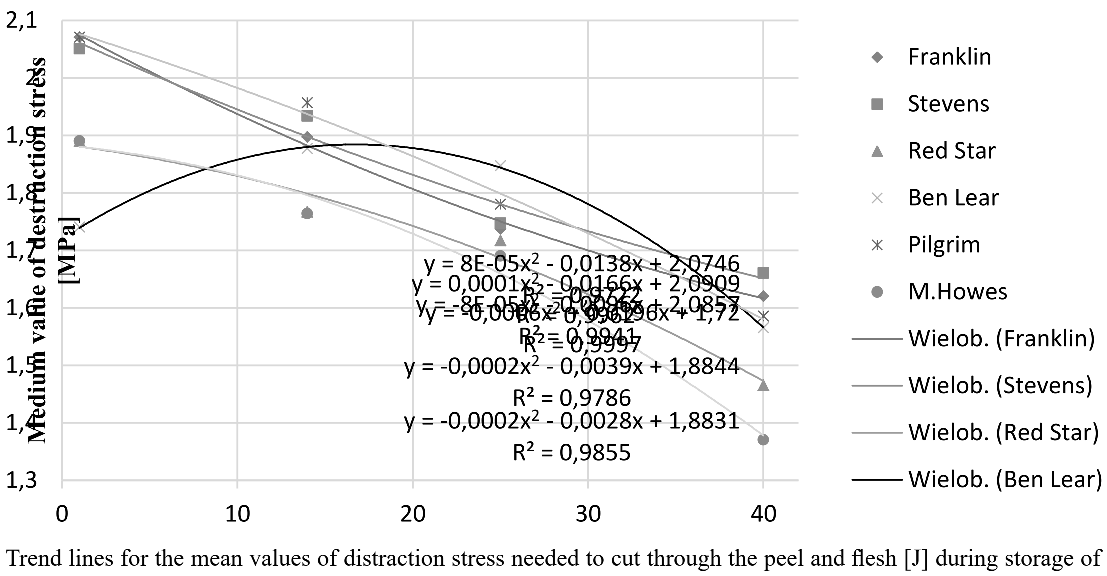

Fig. 6. Trend lines for the mean values of distraction stress needed to cut through the peel and flesh [J] during storage of fruit of large cranberry, regardless of the storage temperature

the decrease in the value of the parameter was affected by the duration of the fruit storage. Coefficients of determination for the mean values of energy needed to cut through the peel and flesh, in relation to the duration of storage, were high and ranged from R^2=0.97 to R^2=0.99.

REFERENCES

1. **Allison D.G., i w sp. 2000.** Influence of cranberry juice on attachment of Escherichia coli to glass. J. Basic Microbiol. 40/2000 r.
2. **Benedycka Z., Bieniek A., Krzebietke S., 2006.** Wpływ zróżnicowanego nawożenia N, P, K, S na zawartość makroskładników w owocach żurawiny wielkoowocowej. Acta Agrophysica, 7(4), 821-827
3. **Bloom C. 2006.** Systematyka rodzaju Oxycoccus. The CompleatBotanica.
4. **Bohdziewicz, J. (2006b).** Właściwości mechaniczne warzyw o kształcie kulistym. Inżynieria Rolnicza, 5(80), 49-57.
5. **Bohdziewicz, J., Czachor, G. 2010.** Wpływ obciążenia na przebieg odkształcenia warzyw o kształcie kulistym. Inżynieria Rolnicza, 1(119), 85-91.
6. **Bohdziewicz, J., Czachor, G. 2010.** Wpływ obciążenia na przebieg odkształcenia warzyw o kształcie kulistym. Inżynieria Rolnicza, 1(119), 85-91.
7. **Braun M., i Pawlaczyk P., Zblewski R.. 2009.** Inwazyjne gatunki roślin ekosystemów mokradłowych Polski: Żurawina wielkoowocowa Oxycoccus macrocarpos. Wydawnictwo Klubu Przyrodników. Świebodzin. 114-118
8. **Brown O. A., McNeil N. J., 2006.** Fruit production in cranberry (Ericaceae: Vaccinium macrocarpon): A bed-hedgingstrategy to optimizereproductiveeffort. American Journal of Botany 93(6), 910–916
9. **Conejero G. V., 2014.** Arándanorojo I (Vaccinium macrocarpon Ait.). Reduca (Biología). Serie Botánica. 7 (2), 100-112
10. **Davenport R. J., DeMoranville C., Hart J. M., Strik B. C., Roper T., 2015.** Cranberries. A nutrien management quide for South Coastal Oregon. OSU. Exstension service. EM 8672 , 2- 51
11. **Gniewosz M., Miętuszewska A., Stobnicka A., 2011.** Przeciwbakteryjne działanie soków owocowych z żurawiny, rokitnika, noni i goji. Bromat. Chem. Toksykol. – XLIV, 3, 650-655.
12. **Górecka A. 2005.** Amerykańska żurawina unikalne zbiory i właściwości zdrowotne. Przemysł spożywczy (12), 35-37
13. **Grzemski, P., Bohdziewicz, J. 2012.** Właściwości reologiczne owoców wybranych odmian śliwy. Inżynieria Rolnicza, 2(137), 45-55.
14. **Howell A.B., Vorsa N., Marderosian A.D., Foo L.X. 1998.** Inhibition of the adherence of P-fimbriated Escherichia coli to uroepithelial-cellsurfaces by proanthocyanidin extracts from cranberries. N. Engl. J. Med.
15. **Kędzia- Hołderna E.,2006.** Charakterystyka botaniczna, skład chemiczny i właściwości biologiczne owoców żurawiny amerykańskiej (Vaccinium macrocarpon Aiton). Postępy Fitoterapii 1, s. 41-46.
16. **Krzewińska D., Smolarz K. 2008.** Wpływ nawożenia na wzrost i owocowanie żurawiny wielkoowocowej Vaccinium macrocarpon Ait. Zeszyty naukowe instytutu sadownictwa i kwiaciarstwa. T. 16, 206-210.
17. **Oszmiański J., Kolniak-Ostek J., Lachowicz S., Gorzelany J., Matłok N., 2015.** Effect of dried powder preparation process on polyphenolic contentand antioxidant capacity of cranberry (Vaccinium macrocarpon L.). Industrial Crops and Products 77, 658-665.
18. **Rabcewicz Jacek;** Perspektywy mechanicznego zbioru owoców pestkowych i jagodowych, Informator sadowniczy 5/2013
19. **Schmidt D.R., Sobota A.E.:** An examination of the anti-adherencea ctivity of cranberry juice on urinary and nonurinary bacteriali solates. Microbios 1988 r.
20. **Schwartz J.H., Medrek T.F.:** Antifungal properties of cranberry juice. Appl. Microbiol. 1968 r.
21. **Teleszko M., 2011.** Żurawina wielkoowocowa – możliwości wykorzystania do produkcji biożywności. Żywność. Nauka. Technologia. Jakość. 6 (79), 132-141.

OCENA WYBRANYCH WŁAŚCIWOŚCI FIZYCZNYCH ŚWIEŻYCH ORAZ PRZECHOWYWANYCH OWOCÓW ŻURAWINY WIELKOOWOCOWEJ

Streszczenie. W pracy określono wybrane właściwości mechaniczne świeżych oraz przechowywanych owoców żurawiny wielkoowocowej. Przeanalizowano zmiany wartości parametru siły przebicia skórki i miąższu wytypowanych odmian żurawiny w zależności od zawartości wody i czasu przechowywania. Dokonano również pomiarów odkształcenia i energii potrzebnej do przebicia skórki i miąższu. Obliczono wartość naprężenia niszczącego. Stwierdzono spadek analizowanych parametrów w czasie przechowywania w owocach analizowanych odmianach żurawiny wielkoowocowej. Średnia zawartość wody w owocach analizowanych odmianach mieściła się w przedziale 86,4-89,1%. Odnotowano spadek średniej wartość siły przebicia skórki i miąższu owoców analizowanych odmian żurawiny wielkoowocowej. Średnia wartość siły przebicia skórki i miąższu dla świeżych owoców żurawiny wynosiła 6,1 N po 40 dniach przechowywania odnotowano spadek wartości o 2,3 N.

Słowa kluczowe: żurawina wielkoowocowa, właściwości mechaniczne, siła przebicia skórki i miąższu, zawartość wody.