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QUALITY CHANGES IN GREAT PUMPKINS AND COLOURED POTATOES DURING STORAGE

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Abstract. Harvested potatoes and pumpkins are usually stored before processing or consumption. This makes it critical to understand the effect of storage on the chemical composition changes in these products. Prolonged storage can cause a decrease/increase or maintain the level of some nutrient. The objective of this study was to investigate the changes in chemical composition during storage of the great pumpkin cvs. 'Justynka F_1', 'Karowita', 'Amazonka' fruit flesh and the coloured fleshed potato cvs. 'Blue Congo', 'Vitelotte' and 'Blue Danube' tubers. Standard methods were applied to determine the following: dry matter, crude fibre, crude ash and weight loss. After four months of storage, the dry matter content significantly increased in all potato cultivars tubers. The largest increase in dry matter was measured in tubers of 'Blue Congo' (2.34%). During storage, crude ash content changed non-significantly in all cultivars. Crude fibre content decreased significantly in 'Blue Danube' (1.02%) and 'Vitelotte' (0.50%) tubers. After four months of storage the largest weight losses were found in tubers of 'Vitelotte'. After storage period dry matter significantly decreased in all tested pumpkin cultivars. The maximum dry matter and weight loss decrease was found in flesh of 'Justynka F_1' (5.36%). The content of crude ash tended to increase in flesh of all cultivars, but no significant differences were found before and after storage period. Crude fibre content significantly decreased in all pumpkin cultivars. The highest crude fibre decrease was found in flesh of 'Justynka F_1' (17.05%).

Key words: great pumpkin, coloured fleshed potato, storage, quality

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INTRODUCTION

Potato is one of the most important vegetable and a part of a daily food utilization of almost all of the world population [Mathur 2003]. The nutrient value of potato is excellent as it has carbohydrate in abundance, protein of superior quality, minerals and fibers in appreciable amount [Srivastava and Kumar 2012]. Recently, colored (yellow-, red- and purple-fleshed) potatoes have attracted the attention of investigators as well as consumers due to their antioxidant activities, taste and appearance. The antioxidant activity in colored potatoes is associated with the presence of polyphenols anthocyanins, flavonoids, carotenoids, ascorbic acid, tocopherols, alpha-lipoic acid and selenium [Jansen and Flamme 2006, Jarienė et al. 2013]. Pumpkins are also rich in carbohydrate and minerals and are cheaper source of vitamins, especially carotenoid pigments, which have a major role in nutrition in the form of pro-vitamin A, antioxidants, when used at ripening stage [Dutta et al. 2006].

Harvested potatoes can be stored for up to one year before being processed or consumed [Herrman et al. 1996]. Potatoe storage, even under the best conditions, affects the chemical composition of the tubers. The qualitative features of potatoes can depend on various factors occurring both during cultivation and storage. Storage losses of potatoes are often specified as weight and quality losses and are caused mainly by respiration, sprouting, spread of diseases, dehydration, changes in chemical composition of the tuber or damage by extreme temperatures [Brook et al. 1995, Wszelaczynska et al. 2007, Pranaitienė et al. 2008].

Pumpkin has also a long storage capacity. Well matured pumpkin fruits can be stored for 2–4 months under normal home conditions. The best time for harvesting is when they are ripped and can be easily picked. Then the most biologically active materials and palatability remain. According to Rahman et al. [2013] the nutritional value of stored pumpkin fruit deteriorates during storage at higher temperature (27–31°C).

The majority of the physico-chemical changes that occur in the harvested commodities are related to oxidative metabolism, which is highly correlated with change in quality and storage duration [Graee and Aarseth 1993, Brook et al. 1995, Maiti et al. 2006].

The aim of this research was to investigate the changes in the chemical composition during storage of the great pumpkin cvs. 'Justynka F_1', 'Karowita', 'Amazonka' fruit flesh and the coloured fleshed potato cvs. 'Blue Congo', 'Vitelotte' and 'Blue Danube' tubers.

MATERIALS AND METHODS

Materials. The following great pumpkin and coloured fleshed potato cultivars were selected for the investigations: *Cucurbita maxima* D. – 'Justynka F_1', 'Karowita' and 'Amazonka', grown in ecological farm in Kaunas district; *Solanum tuberosum* L. – the blue fleshed potato 'Blue Congo', 'Vitelotte' and yellow fleshed potato 'Blue Danube', grown in ecological farm in Prienai district.

Storage conditions. Potatoes and pumpkins were harvested in September. Potatoes were stored in no fenestrate polyethylene bags of 120 μm thickness, separately for each cultivar at temperature of 5–6°C and relative humidity of 85–75%. Pumpkin fruits were stored at temperature of 15°C, relative humidity 70%. Potato tubers and pumpkins of every treatment (four replications for storage researches and three replications for determination of chemical composition) were stored for four months (from October until January).

Preparation of the samples. The peel and seeds of pumpkin fruits were removed and the flesh cut into 2–3 mm thick slices. Potato tubers were brushed, washed and sliced (1.0–1.5 mm thick). Prepared pieces of raw material uniformly layered in a tray were dried for 24 hours at a temperature of 55°C in a dryer with system forced air flow (Venticell 111-Comfort). The dried material was ground on a GRINDOMIX GM-200 knife-mill. The obtained flour was packed in airtight containers prior to use.

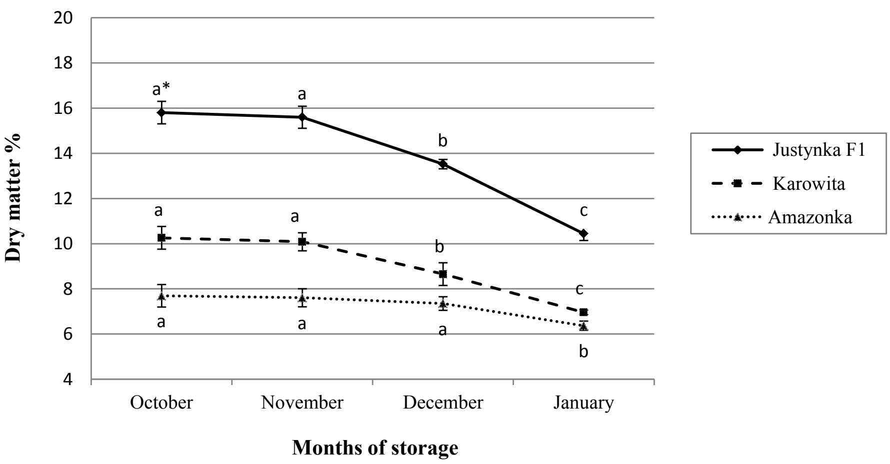
Proximate analysis. Every month in triplicate measurements the content of dry matter was determined by drying samples at temperature of 105°C until the constant weight [ISO 751:2000]. Contents of crude fiber and crude ash were determined according to the method of Heneberg-Shtoman [Methodenbuch-VDLUFA 1983–1999]. Weight losses were assessed and estimated before and after the storage. The weight of pumpkin fruits and potato tubers was determined by weighting on electronic scales (±0.001 g.). Data was provided in percentage.

Chemical analysis of potato tubers and pumpkin fruits were conducted in the laboratory of Food Raw Materials, Agronomical and Zoo-technical Investigations and in the laboratory of Food Technologies of Institute of Agriculture and Food Sciences at the Aleksandras Stulginskis University.

Statistical analysis. The experimental data was statistically processed by the dispersion analysis method (ANOVA), software STATISTIKA 7.0 (StatSoft, USA). Tukey test ($p < 0.05$) was applied to estimate statistical significance of differences. Arithmetic means and standard deviations of research data was calculated. Vertical bars graphed in figures indicated standard deviation.

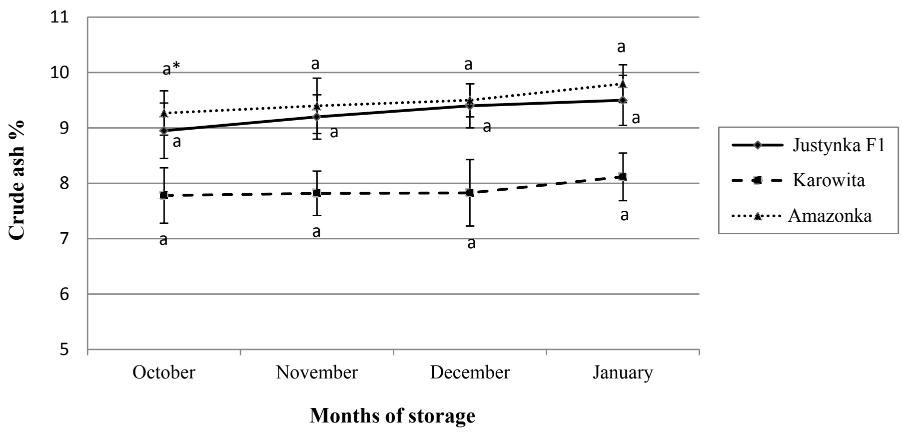
RESULTS AND DISCUSSION

Pumpkins. Dry matter is one of the most important indicators of chemical composition, which ensures the quality and output of the recycled products. Great pumpkins that are grown in Lithuania can accumulate 7.41–22.20% of dry matter [Danilcenko et al. 2007]. According to literary data, before storage the fruits of pumpkins have higher amount of dry matter than after storage period [Biesiada et al. 2009, Nawirska-Olszańska 2011]. Sojak et al. [2014] also established a lower dry matter content in pumpkin fruits after storage. The results of our study showed that the amount of dry matter in all tested pumpkin cvs. fruit flesh decreased with increasing storage period (fig. 1). The loss of dry matter can be related with the general natural changes in the pumpkin fruits during maturation and storage [Arvayo-Ortiz et al. 1994, Iacuzzo and Dalla-Costy 2009]. The flesh of cv. 'Justynka F_1' accumulated the highest amount of dry matter (at the beginning of storage period – 15.80%), however the maximum dry matter decrease was also indicated in the flesh of this cultivar (5.36%). Significant differences in dry matter content between the pumpkin cultivars were found throughout the whole storage period. The respiratory process depletes carbohydrates, organic acids, fats and other substances, which results losses in dry matter during storage.



* – different letters indicate statistical differences, $p < 0.05$

Fig. 1. Dry matter content in different pumpkin cultivar fruits' during storage period, %



* – different letters indicate statistical differences, $p < 0.05$

Fig. 2. Crude ash content in different pumpkin cultivar fruits' during storage period, %

Minerals are naturally occurring inorganic substances with a definite chemical composition and an ordered atomic arrangement [Rumeza et al. 2006]. Vegetables are the excellent source of minerals. Minerals are very important and essential ingredients of diet required for normal metabolic activities of body tissues. Out of 92 naturally occurring minerals 25 are present in living organisms. They are constituents of bones, teeth, blood, muscles, hair and nerve cells. It was found, that the fruits of cv. 'Amazonka' are rich in crude ash (9.27% in dry matter). From October to January the content of crude ash tended to increase in all cultivars flesh – in 'Justynka F_1' (6.15 %), in 'Karowita' (4.37 %), in 'Amazonka' (5.72 %) (fig. 2). By other authors similar results were estimated that during storage in pumpkin flesh increased the content of different minerals [Akwaowo 2000, Nawirska-Olszańska 2011]. No significant differences in quantity of crude ash were found before and after storage period.

Fresh pumpkin fruits are a good source of fibre. The majority of studies indicate that an increase in either soluble or insoluble fibre intake increases postmeal satiety, decreases subsequent hunger, have protective effect for middle-aged women on breast cancer incidence [Willett et al. 1992, Howarth et al. 2001]. Reduced risk for coronary heart disease was associated with greater intake of fibre from vegetable foods [Threapleton et al. 2013]. According to our results the highest amount of crude fibre was fixed in flesh of cv. 'Amazonka' (15.61%). The values of crude fibre in all tested pumpkin cultivars showed a progressive decrease during the whole storage period at 15°C and at relative humidity of 70% (fig. 3). The maximum crude fibre decrease was identified in flesh of cv. 'Justynka F_1' (17.05%). The average crude fiber decrease in pumpkin cultivars was 13.68%. Nawirska-Olszańska [2011] noticed that after 3 months of storage smaller quantities of fibre fraction NDF and ADF have been identified in *Cucurbita maxima* fruits. This may be related to a lower crude fiber content. Crude fiber can decrease due to hemicellulose and other structural polysaccharides degradation during storage [Wani and Sood 2014].

Loss in weight for all three pumpkin cultivars increased with increasing storage period. Harvested vegetables continue to respire and loose water [Thompson 1996, Burdon 1997]. It was observed that cv. 'Justynka F_1' suffered significantly higher weight loss compared to cvs. 'Karowita' and 'Amazonka' (fig. 4). The loss was 5.36% after

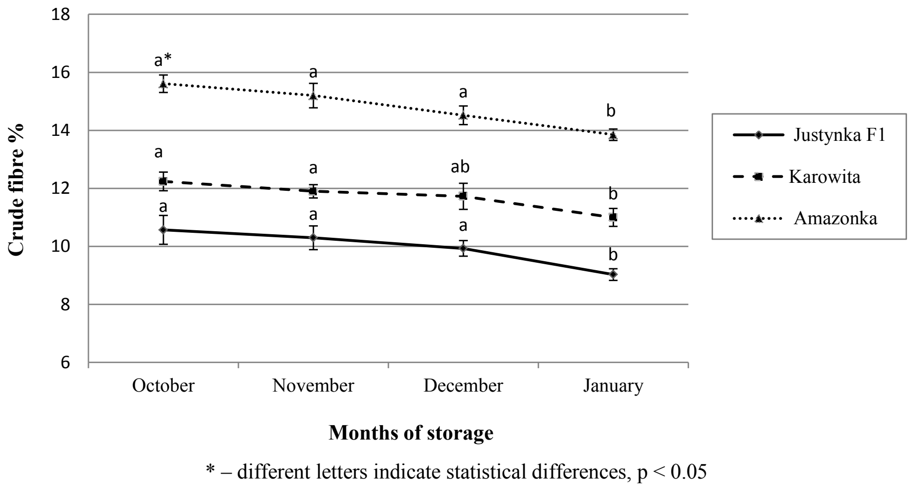
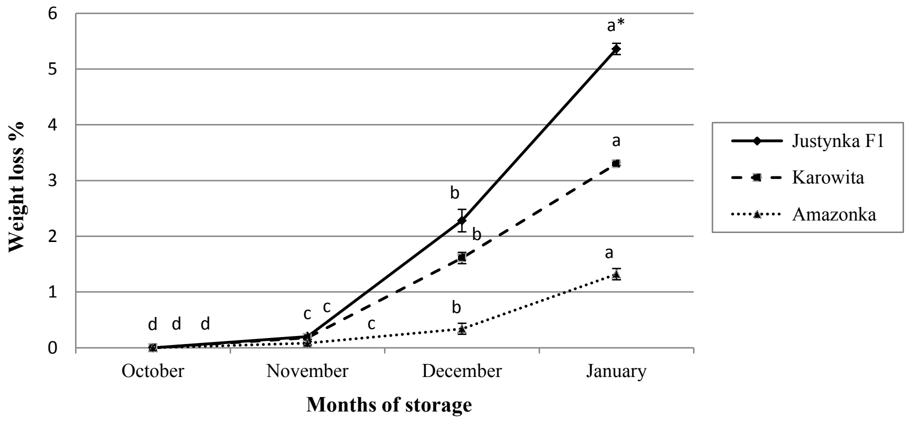


Fig. 3. Crude fibre content in different pumpkin cultivar fruits' during storage period, %



* – different letters indicate statistical differences, $p < 0.05$

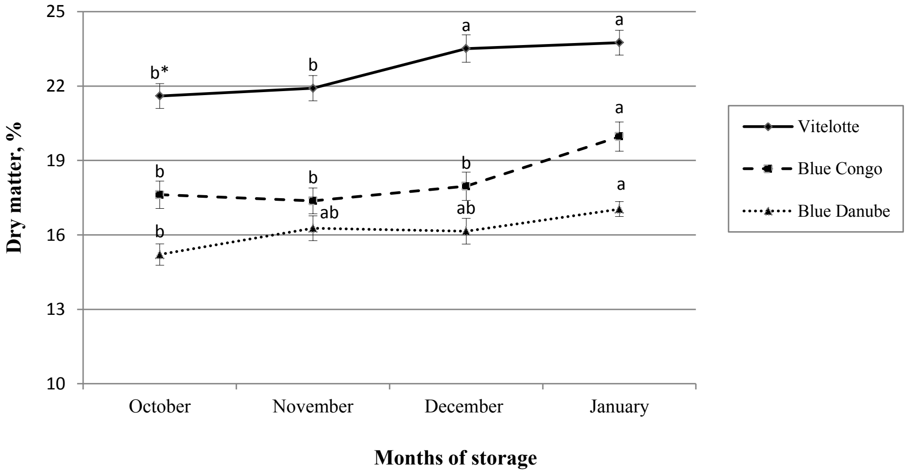
Fig. 4. Weight losses in different pumpkin cultivar fruits' during storage period, %

four months of storage for 'Justynka F_1'. Significant differences in weight loss between the pumpkin cultivars were found from second to fourth month of storage.

Potatoes. The amount of dry matter of potato tubers is one of the main indicators of quality of chemical composition in determining the processing of the product quality and yield. Depending on the cultivar, the amounts of dry matter in potato tubers could range from 16 to 32% of fresh material [Hassanpanah et al. 2011]. Our results showed that the dry matter content at the beginning ranged from 15.21% (cv. 'Blue Danube') to 21.60 % (cv. 'Vitelotte'). After a period of four months of storage, the dry matter content significantly increased in all potato cultivars tubers (fig. 5). The largest increase in dry matter was measured in tubers of cultivar 'Blue Congo' (2.34%), the smallest increase – 'Blue Danube' (1.83%). Changes of dry matter content during storage period can be related to the increase in the transpiration rate of the tubers due to tuber life processes [Burton et al. 1992, Galoburda et al. 2013].

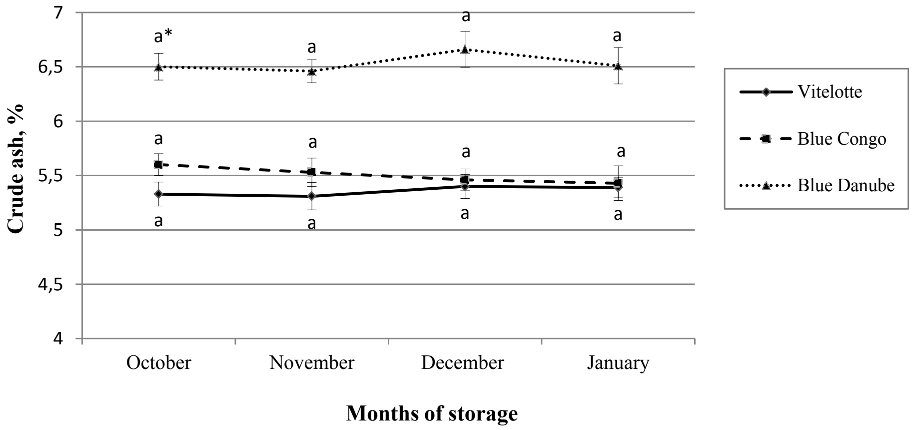
Potato, as a major staple food crop, play an important role to combat mineral deficiencies through its relatively high mineral content. Variation in ash may be a varietal character [Sandhu and Parhawk 2002]. The research performed by us indicates that the crude ash content of tested potato cultivars at the beginning ranged from 5.33 to 6.50%. The highest amount of crude ash was accumulated in cv. 'Blue Danube' potato tubers. After a period of four months of storage, crude ash content didn't show any significant change (fig. 6). The sparse information available indicates that changes in ash content during storage are insignificant. Toma et al. [1978] also reported that the total ash content of two cultivars at 3°C or of six cultivars at 7°C over a period of four to eight months of storage hasn't changed.

Another nutritionally important component of tuber is dietary fibre, which is made from insoluble of cellulose fractions (cellulose and lignin), pectins and hemicelluloses (soluble cellulose fraction) [Gumul et al. 2011]. It was found that fibre content of potato tubers differed significantly in all cultivars. The highest fibre content 2.95% was recorded in cv. 'Blue Danube' and the lowest 1.12% were observed in cv. 'Blue Congo'.



* – different letters indicate statistical differences, p < 0.05

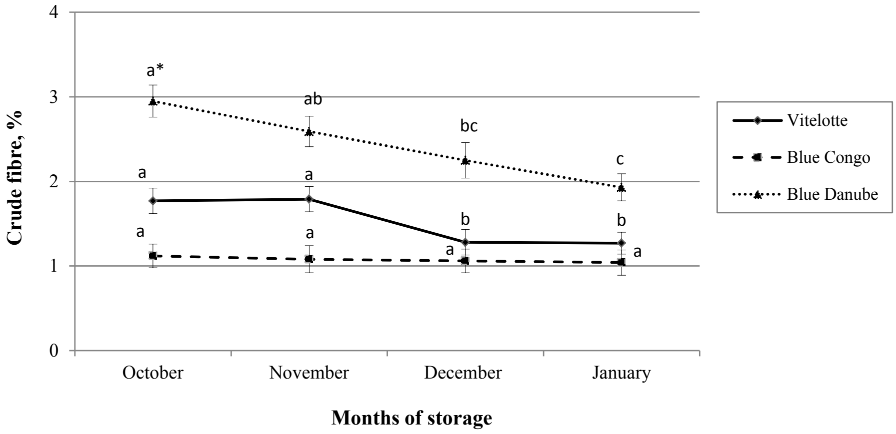
Fig. 5. Dry matter content in different potato cultivars' tubers' during storage period, %



* – different letters indicate statistical differences, p < 0.05

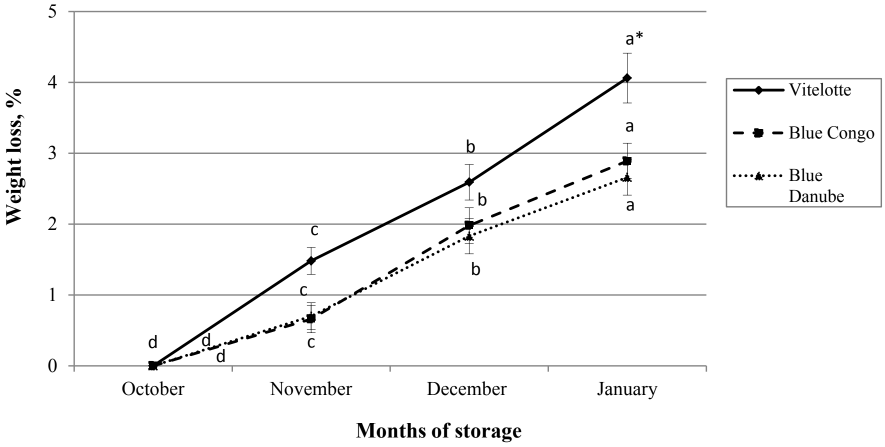
Fig. 6. Crude ash content in different potato cultivars' tubers' during storage period, %

After storage period crude fibre amount decreased non-significantly in cv. 'Blue Congo', but in cvs. 'Blue Danube' and 'Vitelotte' – decreased significantly (fig. 7). It could be conducted that the main factor influencing the different changes of fibre was the cultivar. During the potato tubers storage period the activity of enzymes becomes active as much as possible because the dormancy stage ends and the polysaccharides



* – different letters indicate statistical differences, $p < 0.05$

Fig. 7. Crude fibre content in potato cultivars' tubers' during storage period, %



* – different letters indicate statistical differences, $p < 0.05$

Fig. 8. Total weight losses in potato cultivars' tubers' during storage period, %

were hydrolysed till monosaccharides (glucose, xylose etc.), which are directly participating in the process of the tubers respirations.

The most important means of weight loss are: respiration, evaporation and sprouting. The agents, which influence the extent of weight loss are: quality of potato skin as well as injury during harvesting and storing; temperature, humidity during storage; length of storage as well as subsequent sprouting [Abong et al. 2009]. The result of our research showed that after the four month storage periods the weight losses were between 2.66 and 4.06% (fig. 8.). All potato cultivars showed a gradual weight loss during storage period at temperature (5–6°C) and relative humidity (85–90%). It was observed that cv. 'Vitelotte' suffered significantly more weight compared to cvs. 'Blue Congo' and 'Blue Danube'. It may be due to the more openings of lenticels than other cultivars. Less weight loss in cultivars 'Blue Congo' and 'Blue Danube' may be due to better integrity of skin tissues.

CONCLUSIONS

After four months of storage dry matter significantly decreased in fruits of all tested pumpkin cultivars. Crude ash content had a tendency to increase in all cultivars: 'Justynka F_1' (6.15%), 'Karowita' (4.37 %), 'Amazonka' (5.72%). The content of crude fibre was significantly lower in all pumpkin cultivars compared with the beginning of the storage. The best time to consume pumpkin fruits is primarily in their fresh state or in the three months after the harvesting (until the end of November), based on an assessment of dry matter and weight loss results. After four months of storage, the dry matter content significantly increased in tubers of all potato cultivars. Crude fibre content showed a tendency to decrease in cultivar 'Blue Congo' (0.08%), but in cvs. 'Blue Danube' (1.02%) and 'Vitelotte' (0.50%) decreased significantly. During storage, crude ash content changed non-significantly in all cultivars. After four months of storage the largest weight losses were calculated in tubers of cultivar 'Vitelotte'. Further studies are required to optimize the storage conditions for great pumpkins and colored potatoes for maintaining better fruit quality during storage.

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ZMIANY CECH JAKOŚCIOWYCH OWOCÓW DYNI OLBRZYMIEJ I BULW ZIEMNIAKÓW O KOLOROWYM MIĄŻSZU PODCZAS PRZECHOWYWANIA

Streszczenie. Bulwy ziemniaka i owoce dyni olbrzymiej muszą być zwykle przechowywane, zanim zostaną zużytkowane do konsumpcji lub przetwórstwa, a to sprawia, że przechowywanie ma kluczowe znaczenie dla zmian zachodzących w składzie chemicznym tych produktów. Długotrwałe przechowywanie może wpłynąć na zmianę zawartości niektórych składników odżywczych. Głównym celem pracy było zbadanie zmian składu chemicznego podczas przechowywania owoców dyni olbrzymiej odmian: ‘Justynka F_1’, ‘Karowita’, ‘Amazonka’ i bulw ziemniaka o kolorowym miąższu odmian: ‘Blue Congo’, ‘Vitelotte’ and ‘Blue Danube’. Do oznaczenia suchej masy, włókna surowego, popiołu i ubytków masy zastosowano standardowe metody. Na podstawie uzyskanych wyników wnioskuje się, że po czterech miesiącach przechowywania zawartość suchej masy w bulwach ziemniaka znacznie wzrosła u wszystkich odmian. Największy wzrost suchej masy stwierdzono w bulwach odmiany ‘Blue Congo’ (2,34%). Podczas przechowywania zawartość popiołu surowego w bulwach wszystkich odmian nie zmieniła się istotnie, natomiast zawartość włókna surowego zmniejszyła się w miąższu odmian ‘Blue Danube’ (1,02%) i ‘Vitelotte’ (0,50%). Największy ubytek masy podczas przechowywania odnotowano w przypadku bulw odmiany ‘Vitelotte’. Po przechowywaniu zawartość suchej masy zmniejszyła się istotnie w przypadku owoców wszystkich odmian dyni. Największy spadek zawartości suchej masy stwierdzono dla owoców odmiany ‘Justynka F_1’ (5,36%). Zawartość popiołu surowego podczas przechowywania wzrosła w miąższu wszystkich odmian dyni – ‘Justynka F1’ o 6,15%, ‘Karowita’ o 4,37%, ‘Amazonka’ o 5,72%. Po zakończeniu przechowywania ilość włókna surowego znacznie zmniejszyła się w owocach wszystkich odmian dyni, a najbardziej w miąższu owoców odmiany ‘Justynka F_1’ (17,05%).

Słowa kluczowe: dynia olbrzymia, ziemniak o kolorowym miąższu, przechowywanie, jakość

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