AcademicPres

Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic ISSN 1842-4309

Not. Bot. Hort. Agrobot. Cluj 36 (2) 2008, 23-27

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Quality of Jerusalem Artichoke (*Helianthus tuberosus* L.) Tubers in Relation to Storage Conditions

Honorata DANILČENKO[1)], Elvyra JARIENĖ[1)], Paulina ALEKNAVIČIENĖ [1)], M. GAJEWSKI[2)]

[1)] *Lithuanian University of Agriculture, LT –53361 Akademija, Kauno r., Lithuania, e-mail: honorata.danilcenko@lzuu.lt*

[2)] *Warsaw University of Life Sciences, Nowoursynowska 166, 02-787 Warszawa, Poland*

Abstract

The influence of storage conditions on quality parameters of Jerusalem artichoke cv. 'Swojecki' was investigated. Tubers were kept in a cold chamber at the temperature of 2°C and RH 90-95% for a period of four months. Three methods of storage were applied: in polypropylene (PP) net bags, in the sand or the peat. During storage period there were systematically determined, using standard methods: weight loss, dry matter, soluble solids, total and reducing sugars content and sucrose content. Results showed that the method of storage strongly affected quality degradation of the tubers. The biggest weight loss after two months of storage were noticed for tubers kept in PP net bags. Storage in the sand or the peat significantly reduced weight loss. When tubers were kept in PP net bags, dry matter after four months of storage was 2.2 times bigger, compared with tubers kept in the sand or the peat. The highest loss of soluble solids (4%) was found after four months of storage in the case of storage tubers in PP net bags. Irrespective of storage conditions, the lowest content of total sugars and sucrose in tubers were found after two months of storage. The biggest concentration of reducing sugars in tissue was found in tubers kept in PP net bags.

Keywords: Jerusalem artichoke, *Helianthus tuberosus* L., storage, quality, sugars

Introduction

Jerusalem artichoke (*Helianthus tuberosus* L.) originates from America, but exact region of its origin still remains controversial (Chekroun et al., 1994). It is an alternative plant, useful in many ways. It is interesting because of high sugars content, primarily inulin, productivity and possibilities of cultivation on marginal land. Jerusalem artichoke is a good source of fructose, useful in food industry and for pharmaceuticals (Chekroun et al., 1994).

In Lithuania and in Poland this plant is a valuable vegetable, however so far not very popular. Due to the tendency to vegetable production diversification, its popularity increases in the world.

There are Polish cultivars of this plant, grown also in Lithuania. Studies on nutritive value of Jerusalem artichoke tubers showed that they contain some healthy-promoting components. Tubers contain 20.4 - 31.9% of dry matter, from which carbohydrates are the main component. Most of carbohydrates consists of water-soluble inulin. Concentration of inulin reaches 50 - 56% of dry matter or 11.3 - 14.2 g 100 g^{-1} of fresh mass of tubers. Soluble carbohydrates, besides inulin, are its derivatives – fructo-oligosaccharides, reducing sugars (fructose and glucose) and sucrose.

Beside soluble carbohydrates, tubers contain also dietary fibre, i.e. insoluble, cellulose fractions (cellulose and lignin), pectins and hemicelluloses (soluble cellulose fraction) (Cieślik et al., 2005).

Usually, simple methods of storage for Jerusalem artichoke tubers are applied, for example regular storehouses or overwintering tubers in an open field.

Overwintering is not costly, but technologically risky method, since in a colder climate some freezing injuries may occur, and also it is impossible to pick up the tubers from the soil during winter (Schorr-Galindo and Guiraud, 1997).

In cold stores tubers of Jerusalem artichoke can be kept at the temperature of 0 to 2°C and RH 90 to 95% for several months. However, storage of harvested tubers usually results in high losses in quality, caused mainly by dessication, rotting, sprouting, freezing, and inulin degradation.

Some cultivars are much more susceptible to storage losses, but there are no reports on the influence of storage conditions on quality changes. These troubles in storage can result from the fact that tubers lack of a corky surface layer, similar to that found on potatoes, which could reduce transpiration, but have a thin, easily damaged surface that permits rapid water loss (Modler et al., 1993; Saengthobpinit et al., 2005). Therefore simple, not costly storage technologies of Jerusalem artichoke to reduce losses are demanded. Besides quality degradation, tubers undergo significant alterations in carbohydrate chemistry during storage, which can affect tubers marketability. Inulin consists of a series of molecules of varying chain length, which begin to depolymerize during storage of tubers, whether harvested or left *in situ* (Schorr-Galindo and Guiraud, 1997).

The aim of this study was to determine changes in some parameters of quality of Jerusalem artichoke tubers during storage in different conditions and to compare different storage methods in respect of possibilities of quality degradation reduction.

Material and methods

The experiment was performed in 2006–2007 on Jerusalem artichoke cultivar 'Swojecki'. This cultivar is commonly cultivated in Lithuania and Poland. Plants were grown at the experimental field of Lithuanian University of Agriculture in Kaunas, in the soil of following characteristics: neutral, medium humus, limnoglacial loam on moraine loam, calcareous deeper gleyic luvisol, medium phosphorus rich and medium potassium rich (Table 1).

Tubers were planted out at the end of April, and harvested at the beginning of November. During growing season the temperature and rainfalls were very similar to the medium, except August, when amount of rainfalls, equals 100 mm, exceed medium. Tubers were stored for four months, from the beginning of November till the end of March of the next year in the chamber with controlled temperature, at the temperature of 2°C (+/–0.5°C) and RH 90-95%. Tubers were kept in following conditions:

Table 1 Characteristics of soil conditions in the field used in the experiment

PH_{KCL}	Humus content (%)	P_2O_5 (mg kg^{-1})	K_2O (mg kg^{-1})
6.6	1.76	126	121

- in polypropylene (PP) bags, capacity of 10 kg,
- in a bulk, covered with a sand (layer 10 cm),
- in a bulk, covered with a peat (layer 10 cm).

The sand and the peat were kept moisture during storage period, to obtain high humidity inside the bulk (near 100% RH). The experiment was done in four replications, with 10 kg of tubers in each.

In the experiment there were determined: weight loss of tubers (in %), dry matter (in %), soluble solids, sugars content (including reducing sugars, total sugars and sucrose). These components were determined immediately after harvest and then during storage at one-month intervals. Sugars were determined by the method described by Bertran, and used as the standard method (LST 1698:2000), soluble solids – with Abbe's refractometer. Dry matter of the tubers was determined by drying at 105°C till constant weight (LST ISO 751:2000). Results were elaborated statistically with ANOVA program. Results were presented as means with ± standard deviation. Differences between means were evaluated on the basis of Fisher LSD test, at the confidence level P = 0.05.

Results and discussion

Storage of Jerusalem artichoke tubers in the sand or the peat, under low temperature conditions at the storehouse, simulates conditions taking place during over wintering in the soil, but without risk of freezing. It can be seen that the method of storage significantly affected quality of tubers, including mass loss. This loss resulted from transpiration process mainly and caused dessication of tubers, which could be detected even visually. The biggest weight loss after two months of storage was found for tubers kept in PP net bags (Table 2).

Similar bags are in common use for storage of potato tubers, and are also commercially applied for Jerusalem artichoke tubers. Application of sand or peat for storage significantly decreased weight loss of tubers. Tubers stored in the sand or the peat for 4 months were still firm and crispy, without signs of spoilage or sprouting, but these stored in net bags were of much worse quality. Other authors reported that dry matter content in Jerusalem artichoke tubers depended upon many factors, such as cultivar, maturity stage and storage conditions. Tubers kept for 30 days at temperature of 18°C can loose above 20% of water (Cabezas et al., 2002). Data from the experiment showed that in freshly harvested Jerusalem artichoke tubers dry matter content reached 16.4% (Table 3). The biggest weight loss after two months of storage was found for tubers stored in PP net bags, where reached 3%. Significant differences between dry matter content for different storage conditions were determined already after the first month of storage, and the lowest dry matter content was found for tubers kept in the peat. After two months of storage, dry matter content for tubers kept in the peat and the sand was similar. After three months of storage dry matter content for tubers kept in the peat and the sand differed from those kept in PP net bags – the difference reached 3%. Soluble solids content in Jerusalem artichoke tubers depended upon storage time and storage conditions. Immediately after harvest soluble solids content was

Table 2 Weight loss of Jerusalem artichoke tubers stored in different conditions (%)

Storage conditions	Months of storage			
	1	2	3	4
PP net bags	4.89e	6.76g	3.19d	5.25f
Sand	0.00a	0.00a	0.96b	1.97c
Peat	0.00a	0.99b	0.00a	0.00a

Note: means followed by the same letter are not significantly different at P≤0.05

Table 3 Dry matter in Jerusalem artichoke tubers stored in different conditions (%)

Storage conditions	Months of storage				
	0	1	2	3	4
PP net bags	16.37a±0.09	17.96bc±0.01	19.39e±0.08	20.49f±0.04	20.5f±0.49
Sand	16.37a±0.09	16.45a±0.23	18.21c±0.09	17.47b±0.09	18.23c±0.01
Peat	16.37a±0.09	18.89de±0.15	19.15e±0.47	18.24cd±0.47	18.22c±0.34

Note: means followed by the same letter are not significantly different at P≤0.05

Table 4 Soluble solids content in Jerusalem artichoke tubers stored in different conditions (%)

Storage conditions	Months of storage				
	0	1	2	3	4
PP net bags	16.50f*±0.71	14.73cde±0.671	16.6f±0.19	13.63b±0.07	12.49a±0.06
Sand	16.50f±0.71	15.50e±0.11	14.10bc±0.14	14.40bcd±0.14	15.30e±0.21
Peat	16.50f±0.71	14.99de±0.14	12.52a±0.22	13.96bc±0.07	14.10bc±0.14

Means followed by the same letter are not significantly different at P≤0.05

equal to 16.5% (Table 4). After four months storage, the highest loss of soluble solids (4%) was found for tubers stored in PP net bags. Decreasing of soluble solids content for tubers kept in the sand and the peat was observed up to two months of storage, later this index stabilized and did not change significantly. After two months of storage the highest content of soluble solids (16.6%) was found for tubers kept in PP net bags, and after four months – for tubers kept in the peat (15.3%).

Carbohydrates are the main chemical compounds found in Jerusalem artichoke tubers. Results showed that total sugars concentration in freshly harvested tubers reached 5.25% (Table 5). The lowest amount of these compounds after two months of storage was noted for tubers kept in PP net bags – 4.5%, and about 4.4% or 5% – for tubers kept in the peat or the sand, respectively. After the first month of storage, the lowest concentration was found for tubers kept in the peat (4.8%). After two months significant differences between storage conditions were found.
In this research highest content of reducing sugars during all storage period was found in tubers kept in PP net bags (Table 6). The amount of reducing sugars increased rapidly during storage in tubers stored in these bags, but did not increased so big in tubers kept in the sand.

Jerusalem artichoke is a good source of sucrose. Its content reaches 75% of total carbohydrates amount (Chekroun et al., 1994). Sucrose content in freshly harvested tubers equaled 5.15% (Table 7). Decreasing tendency for sucrose content was observed for all tubers after two months of storage, and in the peat and the PP net bags sucrose content decreased to 4.3% and 4.2%, respectively, and in sand 4.8%. The amount of sucrose in tubers kept indifferent conditions differed already after the first month of storage.

Most enzymatic and chemical reactions are drastically reduced at low temperature, while Jerusalem artichoke tubers metabolism could continue at a slow rate even at the temperature of 2°C during storage (Saengthobpinit et al., 2005). The greatest differences in the quality of stored Jerusalem artichoke tubers resulted from storage conditions. Application of the sand or the peat as the cover for storage strongly affected the rate of transpiration. Tubers of Jerusalem artichoke have a thin and delicate skin and after harvest they are sensitive to water escape.

Table 5 Total sugars content in Jerusalem artichoke tubers stored in different conditions (%)

Storage conditions	Months of storage				
	0	1	2	3	4
PP net bags	5.25gh±0.06	5.29h±0.06	4.53b±0.05	5.18fg±0.01	5.06de±0.007
Sand	5.25gh±0.06	5.26gh±0.04	4.99d±0.04	5.03de±0.01	5.07de±0.01
Peat	5.25gh±0.06	4.81c±0.04	4.43a±0.07	5.09ef±0.02	5.05de±0.02

Note: means followed by the same letter are not significantly different at P≤0.05

Table 6 Reducing sugars content in Jerusalem artichoke tubers stored in different conditions (%)

Storage conditions	Months of storage				
	0	1	2	3	4
PP net bags	0.10a±0.00	0.32d±0.02	0.36e±0.02	0.38e±0.01	0.36e±0.02
Sand	0.10a±0.00	0.11a±0.007	0.17b±0.00	0.19b±0.03	0.17b±0.00
Peat	0.10a±0.00	0.23c±0.03	0.11a±0.007	0.17b±0.00	0.11a±0.00

Note: means followed by the same letter are not significantly different at P≤0.05

26
Table 7 Sucrose content in Jerusalem artichoke tubers stored in different conditions (%)

Storage conditions	Months of storage				
	0	1	2	3	4
PP net bags	5.15h±0.06	4.98g±0.04	4.17a±0.03	4.80e±0.00	4.70d±0.01
Sand	5.15h±0.06	5.16h±0.05	4.83ef±0.04	4.84ef±0.01	4.90fg±0.01
Peat	5.15h±0.06	4.58c±0.01	4.33b±0.06	4.93g±0.02	4.94g±0.02

Note: means followed by the same letter are not significantly different at P≤0.05

Moreover, tubers have branchy shapes and transpire even more easily than other vegetables. It has been demonstrated that by the end of storage weight losses of tubers stored in the peat or the sand were approximately 5 and 3 times lower than in tubers kept in PP net bags. Therefore, storage in the sand or the peat, which allows maintaining high firmness - one of the most important traits of Jerusalem artichoke quality, should be recommended for storage.

Due to a considerably higher transpiration, dry matter of Jerusalem artichoke tubers stored in PP net bags was higher than in tubers kept in the sand or the peat. Irrespective of storage conditions, dry matter of Jerusalem artichoke tubers increased by the end of storage period, and in tubers kept in PP net bags dry matter was bigger than in tubers stored in the peat or the sand.

Storage of Jerusalem artichoke tubers at a low temperature (4°C) for 34 days resulted in increased content of fructo-oligosaccharides (Kang et al., 1993). The structure of carbohydrates depends upon many factors, such as the plant source, the climate and growing conditions, the maturity and storage time.

Jerusalem artichoke tubers kept in PP net bags had more reducing and total sugars than those stored in the peat or the sand. The intensity of physiological processes, which take place in PP net bags is higher, so the reduction of total sugars content in tubers is higher, too. Therefore, active utilization of reducing sugars in cells stimulates the ageing of tubers.

After two month of storage, when the content of total sugars and sucrose decreased noticeably, tubers experienced stress and then acclimatized. During storage the physiological process continued and respiration rate decreased, so the degradation of total sugars and sucrose was irregular it that conditions.

Conclusions

Storage of Jerusalem artichoke tubers results in changes of important quality parameters. However, it can be concluded that storage in the sand or the peat significantly decreases weight loss of tubers compared to usually applied storage of tubers in PP net bags. Tubers stored in PP net bags showed two times more loss of dry matter after four months of storage, compared with tubers kept in moistured sand or peat. Tubers kept in PP net bags showed also the biggest loss of soluble solids after 4-month storage. Irrespective of storage conditions, the lowest total sugars and sucrose content were found in tubers stored for two months. Due to water losses, the highest content of reducing sugars was found in tubers kept in PP net bags. Compared with traditional method of storage tubers in PP net bags, storage tubers in storehouses in a bulk, covered with moistured sand or peat is a good method for reducing their quality degradation and keeping high nutritive value.

References

Barta, J., P. Fodor, S. Torok, K. Vukov, 1990, Mineral components and micro-elements in Jerusalem artichoke tubers grow in Hungary. Acta Alimen. 19, 41-46.

Ben, Chekroun M., J. Amzile, M. El Yachioui, 1994, Qualitative and quantitative development of carbohydrate reserves during the biological cyple of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. New Zealand, J. of Crop and Hort. Sci. 22, 31-37.

Ben, Chekroun M., J. Amzile, M. Mokhtari, N. E. El Haloui, 1996, Comparison of fructose production by 37 cultivars of Jerusalem artichoke (*Helianthus tuberosus* L.). New Zealand J. of Crop and Hort. Sci. 24, 115-120.

Cabezas M. J., C. Rabert, S. Bravo, C. Shene, 2002, Inulin and sugar contents in *Helianthus tuberosus* and *Cichorium intybus* tubers: effect of post harvest storage temperature. J. Food Science 67, 2860-2865.

Cieślik, E., A. Kopeć, W. Praznik, 2005, Healthy properties of Jerusalem artichoke flour (*Helianthus tuberosus* L.). El. J. Polish Agric. Univ., Food Sci. Technol., vol. 8/2/art-37, www.ejpau.media.pl/volume8/issue2/art-37.html.

Kang, S. I., J. I. Han, K. Y. Kim, S. J. Oh, S. I. Kim, 1993, Changes in soluble neutral carbohydrates composition of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers according to harvest date and storage temperature. J. Korean Agric. Chem. Soc. 36, 304-309.

LST ISO 751:2000, Vaisių ir daržovių gaminiai. Vandenyje netirpių sausųjų medžiagų nustatytmas.

LST 1698:2000, Vaisių ir daržovių gaminiai. Cukrų nustatymas.

Modler, H. W., J. D. Jones, G. Mazza, 1993, Observations on long-term storage and processing of Jerusalem artichoke tubers. Food Chem. 48, 279-284.

Saengthobpinit, W., T. Sajjaanantakul, 2005, Influence of harvest time and storage temperature on charecteristics of inulin

from Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. Postharvest Biol. Technol. 37(1), 93-100.

Schorr-Galindo, S., J. P. Guiraud, 1997, Sugar potential of different Jerusalem artichoke cultivars according to harvest. Biores. Tech. 60,15-20.

Soja, G., G. Dersch, W. Prasnik, 1990, Harvest dates, fertilizer and variety effects on yield, concentration and molecular distribution of fructose in Jerusalem artichoke (*Helianthus tuberosus* L.). J. Agron. Crop Sci. 165, 181-189.