J Bangladesh Agril Univ 18(3): 551–556, 2020 https://doi.org/10.5455/JBAU.96310

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Inulin Based Characterization of Turkish Jerusalem Artichokes

Fatih Hancı✉, **Gizem Tuncer, Cihan Kuzu**

Faculty of Agriculture, Erciyes University, 38280, Kayseri, Turkey

ARTICLE INFO

Article history
Received: 13 Jul 2020
Accepted: 16 Sep 2020
Published online: 25 Sep 2020

Keywords
Diversity,
Inulin,
Helianthus,
Prebiotic,
Tuber

Correspondence
Fatih Hanci
✉: fatihhanci@erciyes.edu.tr

ABSTRACT

Although Jerusalem artichoke is not recognized as a commercial plant species that is cultivated in very wide areas, it emerges as a product that increases its popularity due to its high adaptability, relatively easy cultivation and high inulin content in recent years. In this study, the inulin content of Turkish Jerusalem Artichoke accessions was aimed to determine for the first time. Jerusalem artichoke tubers of eighteen accessions, collected from nine different cities of Turkey, were used as plant material. To calculate the amount of inulin in tubers, the hydrolysates were analyzed using spectrophotometer. The results were expressed as percentage of inulin content on dry and fresh weight basis. Inulin contents in dry matter samples of the Jerusalem artichoke accessions were 47.34±12.51% on an average. The highest inulin content (82.34%) was obtained from the genotype 38*1 collected from Kayseri / İncesu; the lowest content (33.79%) was obtained from the accession 50*1 collected from Nevşehir/Gülşehir. The highest inulin yield was obtained from accession 19*3 collected from Çorum/Ferizli (80.13 g/plant). This was followed by genotype 19*1 collected from the same city (66.45 g/plant). Considering the inulin ratios in fresh tubers, the highest result was obtained from accession 38*1 (15.89%). The average inulin content of all accessions was 9.28% / fresh tuber weight. Cluster analyses were performed according to the Ward method and Euclidian distances using inulin contents of accessions in fresh tubers and dry samples. The most distant accessions are 38*1 to 50*1 (diversity coefficient: 49.39); the closest accessions were 19*4 and 40*1 (diversity coefficient: 0.36). All accessions were clustered in two main groups. Both clusters had an equal number of accessions. A high variation was observed in Jerusalem artichoke accessions collected from different regions of Turkey.

Introduction

The Jerusalem artichoke (*Helianthus tuberosus* L.) (2n=102) is a member of *Helianthus* L. genus, *Heliantheae* tribe, *Asteroideae* subfamily, *Asteraceae* family, and *Asterales* order. It grows naturally in the central regions of North America and was taken to France by the French explorer Champlain in the early 1600s, where it has been used as human food and animal feed since the mid-1600s (Heiser, 1978). In France, Jerusalem artichoke has been used for many years in wine and beer production. Today, it is an important plant used in human and animal nutrition and in the production of alcohol and high fructose syrup. This plant is highly resistant to high temperatures and other stress conditions (D'Egidioa *et al.* 1998). It is assumed that the high resistance of the Jerusalem artichoke to various stress conditions may be associated with its fructose metabolism (D'Egidioa *et al.* 1998).

Fructose is an alternative sweetener to natural sugar and sucrose. Sucrose has been reported to cause diabetes, obesity and vascular obstruction whereas fructose increases iron absorption by forming an iron-fructose chelate complex, absorbed more quickly than inorganic iron in humans. Inulin is a natural polysaccharide consisting of fructose chains containing β-2,1 glycoside-linked glucose units. Inulin is a storage carbohydrate found in the roots or tubers of plants such as Jerusalem artichoke, chicory, dahlia. Recently, inulin sources have attracted attention as renewable raw materials in the production of fructose syrup, ethanol and other chemicals (Ertan and Ekinci, 2002). Inulin was first isolated from the *Inula helenium* by the German scientist Rose in 1804, but the definition of inulin was first used by Thompson in 1808. German plant physicist Julius Sachs (1864) has done a lot of research on fructan, and as a result, he obtained pure inulin crystals by precipitating them with ethanol from dahlia, Jerusalem artichoke, and tuberous roots. Inulin is a compound with interesting nutritional and technological properties. In food formulations, it has a wide application. In addition,

Cite This Article

Hanci, F., Tuncer, G., Kuzu, C. 2020. Inulin Based Characterization of Turkish Jerusalem Artichokes. *Journal of Bangladesh Agricultural University*, 18(3): 551–556. https://doi.org/10.5455/JBAU.96310

it significantly improves organoleptic properties in foods. It exhibits oil-like behavior, especially when used in gel form in the water while improving the stability of foams and emulsions in foods. Thanks to such properties, inulin is used as a fat and carbohydrate substitute and provides nutritional benefits and changes in taste and texture. Therefore, inulin has been reported to be an important component that offers new opportunities in the production of balanced and good-tasting foods. It is stated that inulin can be obtained from plant sources, and 15% of flowering plants are a significant source. Inulin-containing plants used in the human diet have been reported in families of *Liliaceae* (onion, asparagus, garlic) and *Compositae* (Jerusalem artichoke, chicory). Due to its high inulin content, chicory, dahlia, and Jerusalem artichoke have been reported to be used in industrial inulin production (Li & Chan-Halbrendt, 2009; Leroy *et al.* 2010).

There are 163 families, 1225 genera, and 9000 species in Turkey's flora, and approximately 3000 species are endemic (Tan, 1995). These data compared with the whole of the European continent which holds 203 families, and 12.000 species (approximately 2.500 endemics), it is understood that Turkey is a rich country in terms of plant genetic resources. Therefore, it has great importance for Turkey of the studies relating to the conservation and use of genetic material. The success in the conservation and utilization programs of plant gene resources includes the systematic determination of the genus and species characteristics of the collected material, keeping detailed records, and monitoring the genetic change in the material. As is known, success in classical breeding depends on selection. This requirement depends on the creation of a wide genetic variation. Genetic resources are important for the development of new and high-yielding varieties using their various characteristics. For this reason, it is very important to identify long term conserved populations in gene banks (Tan, 1988).

Turkey is not a homeland of Jerusalem artichoke, but it has been cultivated for a long time. When considering the very different ecological conditions of Turkey and selections made by the growers over time, it is assumed that great genetic variation can be observed in local Jerusalem artichoke accessions. Based on this assumption, a project is started in 2018 with the title of "Molecular, Biochemical, Morphological Analysis and Selection Studies in Some Local Jerusalem Artichoke (*Helianthus tuberosus* L.) Accessions". Within the scope of this project, local markets were visited in nine different cities during the autumn of 2018 and tubers were obtained, and the materials are evaluated morphologically (Hanci & Tuncer, 2019).

In this study, it was aimed to determine the inulin content of these obtained accessions. According to the findings, the first findings regarding the biochemical characterization of the gene source were obtained.

Materials and Methods

Jerusalem artichoke tubers of eighteen accessions, collected in 2018 November from ten different cities, were stored until March 2019 in the refrigerator (Figure 1). Three nearly equal sized tubers of each accession were planted in a 5-liter pot, and grown until November, 2019, under the same conditions (six pots for each accession, in total 108 pots).

Figure 1. Tubers samples of some genotypes used in the study (Background scale 1 cm^2 each square)

Fertilizer di-ammonium phosphate was applied before one-day transplanting at a rate of 150 kg per ha^{-1}. Any kind of pesticide did not apply during the growing period. Supplementary irrigation was applied to the pots with an overhead sprinkler system at five-day intervals. At harvest, two tubers in each pot (six tubers for each accession) were sampled randomly and used for the determination of inulin content. Tubers were soaked in tap water to eliminate the soils. Fresh tuber fresh weight was determined in the field.

The inulin content of tubers of each accession in the gene pool was determined according to the small modified version of the Puangbut *et al.* (2015) method. The peeled tubers were cut into lengthwise thin pieces. The thus chopped material was soaked in absolute ethanol in the refrigerator (4-5°C) for 24 hours and was stored at -20 °C until analysis. Hundred-gram samples were dried in an oven at 60°C temperature for 24 hours. 1 gram of dehydrated samples was placed in tubes containing 20 ml of distilled water. These tubes were incubated at 80°C water for 20 minutes. The samples cooled at room temperature for 30 min were filtered through a 0.45 µm diameter membrane filter. A half milliliter extract, which was filtered through a membrane filter, was added to a 3% HCL solution diluted in 25 ml distilled water. The mixtures were then heated at 80 °C in a water-bath for 45 minutes. At the end of this period, all solutions were allowed to cool at room temperature. The detailed technique for analysis for inulin content has been reported by Saengkanuk *et al.* (2011) and Puangbut *et al.* (2015). The hydrolysates were then analyzed for inulin using spectrophotometry (A&E Lab. S70-2U, Guangdong, China). Inulin investigation was conferred as a percentage of inulin content on a dry and fresh tuber weight basis. Calculations procedures for statistical analysis were done using JMP and PAST3 software. The data from the experiment were subjected to a general analysis of variance (ANOVA).

Results and Discussion

Inulin contents of the accessions

Inulin contents (%) and inulin yields (g/plant) of eighteen Jerusalem artichoke accessions evaluated in the study are shown in Table 1. The differences between tuber yield for per plant and inulin yield for per plant parameters are statistically significant ($p < 0.01$). Inulin contents in dry matter samples of the Jerusalem artichoke accessions were 47.34±12.51% on average. The highest inulin content (82.34%) was obtained from the genotype 38*1 collected from Kayseri/İncesu; the lowest content (33.79%) was obtained from the accession 50*1 collected from Nevşehir/Gülşehir. However, it is a fact that in practice, the % inulin content of the Jerusalem artichoke does not make sense alone. For plant breeding and industrial production, this parameter should also be combined with the dry matter content of tubers and tuber yield per plant. The dry matter contents of the accessions ranged from 18.99 to 20.33%, with an average of 19.60±0.39%. The variation between accessions was rather narrow.

When fresh tuber yields per plant of accessions were examined, it was found that there was a large variation. Fresh tuber yields of accessions ranged from 54.97 g/plant to 891 g/plant, with an average of 495±230.75 g/plant. Using all three data, the mean inulin yields of each genotype were calculated. Accordingly, the highest inulin yield was obtained from accession 19*3 collected from Çorum/Ferizli (80.13 g/plant). This was followed by genotype 19*1 collected from the same city (66.45 g/plant). Considering the inulin ratios in fresh tubers, the highest result was obtained from accession 38*1 (15.89%). The average inulin content of all accessions was 9.28% / fresh tuber.

Diversity of the accessions based on inulin contents

Cluster analysis was performed according to the Ward method and Euclidian distances using inulin contents of accessions in fresh tubers and dry samples (Figure 2). The most distant accessions are 38*1 to 50*1 (diversity coefficient: 49.39); the closest accessions were 19*4 and 40*1 (diversity coefficient: 0.36). All accessions were clustered in two main groups. Both clusters had an equal number of accessions. Four of the five accessions in which the color of the tubers was red, clustered in the same group while only the accession 19*4 was in the other cluster.

Principal component analysis (PCA) was performed to determine effect of inulin yields and contents on genotypic variation of genotypes. The first principal component represents for highest variability in the data (Leilah and Al-Khateeb, 2005). Only tuber yield per plant (g) value in the first principal component has been above |0,3| (0.997). In the second principal component, two character has reached the value |0,3| (inulin content in dry matter (%) and inulin yield per plant (g); 0.740 and 0.656 respectively). (Table 3). The distributions of the 18 genotypes in a 2- dimensional graph have been presented in Figure 3. The first (PC1) and second (PC2) coordinates of the PCA applied using morphological data accounted for 90,09 % of the diversity monitored.

In one of the most comprehensive studies, Puttha *et al.* (2012) characterized 79 different Jerusalem artichoke accessions in terms of their inulin content. Inulin contents of accessions ranged from 55.3% to 74%. In our study, inulin content in the dry matter ranged from 33.79% to 82.34%. Although the number of accessions assessed was almost a quarter, the variation in inulin content was much greater. In the study of Saengthongpinit *et al.* (2005), the dry matter contents of the Jerusalem artichokes varied according to the harvest time. This rate was 19.63% in tubers which were collected in the 16th week, and 23.55% in the 20th week. These results are close to ours. The average inulin content of fresh tuber in all accessions was 9.28%. Compared with previous reports (Brkljača *et al.* 2014; Li *et al.* 2015; Puttha *et al.* 2012), the yield of inulin extracted from Jerusalem artichoke was similar to other studies.

Table 1. Inulin contents and yields of Turkish Jerusalem Artichoke accessions

Sample	Collection area	IC/DW (%)	TC	TY/P* (g)	DM (%)	IY/P* (g)	IC/FT(%)
38*1	Kayseri/İncesu	82.34^{ns*}	Yellow	303.39^{de}	19.30^{ns*}	48.21$^{b\text{-}e}$	15.89^{ns*}
40*2	Kırsehir	39.61	Yellow	155.25$^{d\text{-}f}$	19.52	12.00$^{f\text{-}g}$	7.73
06*1	Ankara/Beypazarı	53.79	Red	470.88^{cd}	20.10	50.92$^{b\text{-}e}$	10.81
07*1	Antalya/Alanya	51.06	Yellow	598.50$^{a\text{-}d}$	19.88	60.75$^{a\text{-}c}$	10.15
07*2	Antalya/Manavgat	50.03	Yellow	378.00^{cd}	19.56	36.99$^{c\text{-}f}$	9.79
19*1	Çorum/Sungurlu	59.09	Red	571.95$^{a\text{-}d}$	19.66	66.45^{ab}	11.62
19*2	Çorum/Sungurlu	39.09	Red	444.42^{cd}	18.99	32.99$^{d\text{-}f}$	7.42
19*3	Çorum/Ferizli	61.15	Yellow	689.00$^{a\text{-}c}$	19.02	80.13^{a}	11.63
19*4	Çorum	36.70	Red	601.83$^{a\text{-}d}$	19.36	42.76$^{b\text{-}f}$	7.11
33*1	Mersin	41.32	Yellow	387.18^{cd}	19.66	31.45$^{e\text{-}g}$	8.12
40*1	Kırşehir	36.36	Yellow	313.92^{de}	19.22	21.94$^{f\text{-}g}$	6.99
40*3	Kırşehir	40.12	Yellow	54.27^{f}	20.33	4.43^{g}	8.17
50*1	Nevşehir/Gülşehir	33.79	Red	834.21^{ab}	20.12	56.72$^{a\text{-}e}$	6.80
50*2	Nevşehir/Avanos	47.30	Yellow	581.94$^{a\text{-}d}$	19.29	53.10$^{a\text{-}e}$	9.12
50*4	Nevşehir/Ürgüp	37.04	Yellow	819.00^{ab}	20.09	60.95^{abc}	7.44
55*1	Samsun/Vezirköprü	33.97	Yellow	891.00^{a}	19.55	59.17$^{a\text{-}d}$	6.64
58*1	Sivas/Gemerek	53.28	Red	534.51$^{b\text{-}d}$	19.52	55.59$^{a\text{-}e}$	10.40
66*2	Yozgat/Boğazlıyan	56.87	Red	280.80^{de}	19.66	31.40$^{e\text{-}g}$	11.18
Avr		47.34		495.00	19.60	44.77	9.28
Std E		2.95		54.39	0.09	4.65	0.57
Std D		12.51		230.75	0.38	19.71	2.40

Abbreviations: IC/DW: Inulin content in dry matter (%); TC: Tuber color; TY/P: Tuber yield per plant (g); DM: Dry matter (%); IY/P: İnulin yield per plant (g); IC/FT: Inulin content in fresh tuber (%); *significant ($p < 0.01$), ns: not significant; Means within a group that have a different small letter are significantly different from each other; Std E: Standart error; Std D: Standart deviation

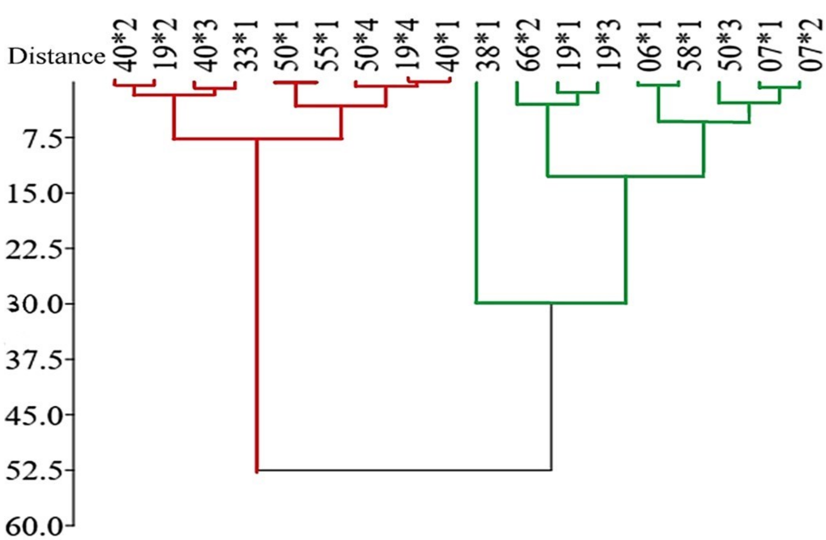

Figure 2. Diagram of cluster analysis considering the content of inulin in fresh tubers and dry samples

Table 2. Eigen values of each character*

	PC 1	PC 2	PC 3	PC 4	PC 5
IC/DW	-0.011	0.740	0.646	-0.071	-0.173
TY/P	0.997	-0.038	0.061	0.000	0.000
DM	0.000	-0.005	-0.001	0.916	-0.401
IY/P	0.071	0.656	-0.751	0.002	-0.002
IC/FT	-0.002	0.141	0.122	0.395	0.899

* Abbreviations: IC/DW: Inulin content in dry matter (%); TC: Tuber color; TY/P: Tuber yield per plant (g); DM: Dry matter (%); IY/P: İnulin yield per plant (g); IC/FT: Inulin content in fresh tuber (%); *significant (p < 0.01), ns: not significant; Means within a group that have a different small letter are significantly different from each other; Std E: Standart error; Std D: Standart deviation

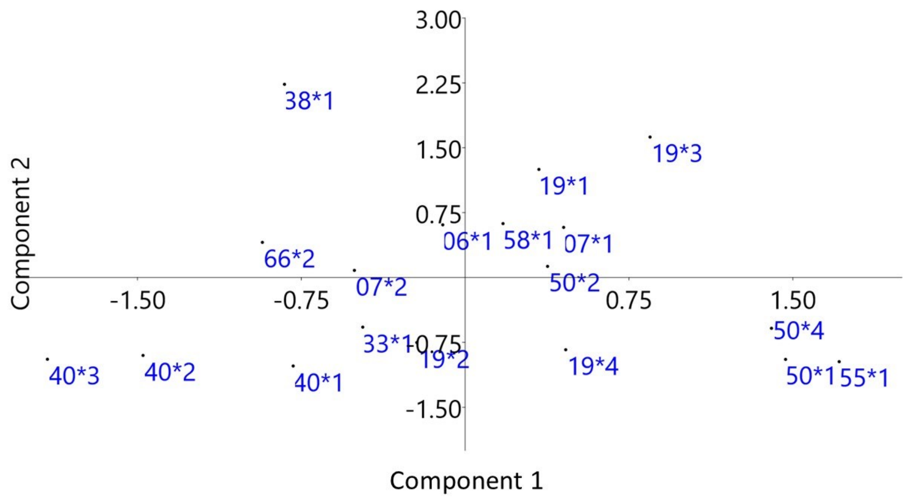

Figure 3. Distribution of Jerusalem artichoke genotypes based on the first and second component

Conclusion

The results of this study provided significant knowledge on the genetic diversity of different Jerusalem artichoke accessions based on the inulin contents. These results should be taken into consideration by the producers, plant breeders and processing industry members. In future studies, detailed physiological analysis under different ecological conditions can be great benefit to plant breeders and food scientists. Also, considering that the entire crop cannot be processed simultaneously in commercial production, the effects of storage on the inulin content may also be the subject of future studies.

Acknowledgements

This work was supported by the Research Fund of the Erciyes University. Project Number: FHD-2018-8595.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

Brkljača, J., Bodroža-Solarov, M., Krulj, J., Terzić, S., Mikić, A., Jeromela. A.M. 2014. Quantification of inulin content in selected accessions of Jerusalem artichoke (*Helianthus tuberosus* L.). *Helia*, 37:105-112. https://doi.org/10.1515/helia-2014-0009

D'Egidio, M.G., Cecchini, C., Cervigni, T., Donini, B., Pignatelli, V. 1998. Production of fructose from cereal stems and polyannual cultures of Jerusalem artichoke. *Industrial Crops Production*, 7:113-119. https://doi.org/10.1016/S0926-6690(97)00039-3

Ertan, F., Ekinci, F. 2002. The production of inulinases from Alternaria alternata, Aspergillus niger, and Trichoderma harzianum. *Journal of Marmara for Pure and Applied Sciences*, 18:7-15.

Hanci, F., Tuncer, G. 2019. The Investigation of the Variation in Tuber Characteristics of Jerusalem Artichoke Collected From Different Provinces of Turkey. Proceeding Book of International Congress on Vocational & Technical Sciences, 24-34.

Heiser, C. B. 1978. Taxonomy of helianthus and origin of domesticated sunflower. In Sunflower Science and Wisconsin (pp. 31–53), ed. J. F. Carter. Madison, WI: Madison Inc. https://doi.org/10.2134/agronmonogr19.c2

Leilah, A.A. and Al-Khateeb, S.A. 2005. Statistical analysis of wheat yield under drought conditions. *Journal of Arid Environment*, 61**:** 483-496. https://doi.org/10.1016/j.jaridenv.2004.10.011

Leroy, G., Grongnet, J.F., Mabeau, S., Le Corre, D., Baty-Julien, C. 2010. Changes in inulin and soluble sugar concentration in artichokes (*Cynara scolymus* L.) during storage. *Journal of Science, Food and Agriculture*, 90,1203–1209. https://doi.org/10.1002/jsfa.3948

Li, S.Z., Chan-Halbrendt, C. 2009. Ethanol production in (the) People's Republic of China: potential and technologies. *Applied Energy*, 86,162–169. https://doi.org/10.1016/j.apenergy.2009.04.047

Li, W., Zhang, J., Yu, C., Li, Q., Dong, F., Wang, G., Gu, G., Guo, Z. 2015. Extraction, degree of polymerization determination and prebiotic effect evaluation of inulin from Jerusalem artichoke. *Carbohydr Polym*, 121: 315–319. https://doi.org/10.1016/j.carbpol.2014.12.055

Puangbut, D., Jogloy, S., Vorasoot, N., Holbrook, C.C., Patanothai, A. 2015. Responses of inulin content and inulin yield of Jerusalem artichoke to seasonal environments. *International Journal of Plant Production*, 9(4): 599-608.

Puttha, R., Jogloy, S., Wangsomnuk, P.P., Srijaranai, S., Kesmala, T., Patanothai, A. 2012. Genotypic variability and genotype by environment interactions for inulin content of Jerusalem artichoke germplasm. *Euphytica*, 183:119–131. https://doi.org/10.1007/s10681-011-0520-0

Saengkanuk, A., Nuchadomrong, S., Jogloy, S., Patanothai, A., Srijaranai, S. 2011. A simplified spectrophotometric method for the determination of inulin in Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. *European Food Research Technology*, 233, 609-616. https://doi.org/10.1007/s00217-011-1552-3

Tan, A. 1988. Current status of plant genetic resources conservation in Turkey. Proceeding book of the International Symposium on In Situ Conservation of Plant Genetic Diversity 5–16.

Tan, A. 1995. Country Report to The Fao International Technical Conference On Plant Genetic Resource, Leipzig.