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Influence of harvest time on carbohydrates content of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers

Research article

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Abstract

Jerusalem artichoke is promoted as a plant with great potential for use due to its specific chemical composition, having inulin as a reserve carbohydrate, unlike other plants that contain starch. Because the tubers deteriorate very easily during storage, it is recommended that the harvest be carried out according to use.

In this work the soluble solids, inulin and reducing sugars content of three Jerusalem artichoke cultivars (Dacic, Rares and Dabuleni) grown at Agricultural Research Development Station Caracal was evaluated at two harvest times (autumn and spring). The obtained results show that the studied chemical indices vary depending on the analyzed cultivar and the stage of plant development. The tubers of the experimented Jerusalem artichoke cultivars present appreciable content of soluble solids and inulin at both harvest times. In all investigated cultivars, tubers harvested in spring have lower content of inulin and soluble solids and higher content of reducing sugars than those harvested in autumn.

Keywords: Jerusalem artichoke, harvest time, inulin, sugars, soluble solids.

1. INTRODUCTION

Jerusalem artichoke (Helianthus tuberosus L.), topinambur is a perennial plant with nutritional and therapeutic properties that has a special importance due to its multiple uses.

Tubers have a complex chemical composition. They contain around 2% protein of high biological value with favorable proportions of all essential amino acids, they are a rich source of vitamins: vitamin B complex, folates and folic acid, ascorbic acid and β-carotene and compounds with antioxidant properties, especially polyphenols [1-4]. Jerusalem artichoke tubers have a high iron, calcium and potassium content and they have relatively little sodium [5].

Other components of Jerusalem artichoke are carbohydrates. The main carbohydrate present is inulin whose content ranges from 7 to 30% of fresh weight, around 50% of dry weight [1, 6-12]. Inulin is a reserved polysaccharide constituted by fructose molecules linked by β (2→1) bonds, with a terminal glucose unit linked by an α (1→2) bond [7]. The structure of carbohydrates influences its nutritional quality and industrial uses. Due to its specific chemical composition Jerusalem artichoke has multiple uses in the food, pharmaceutical, bioethanol and biochemical compounds industry [13, 14]. The rich content in fermentable carbohydrates make it a significant raw material for producing energy such as bioethanol, biobuthanol, methane, biodiesel and chemical products. In the food industry, it is used as a raw material for obtaining flour, inulin, fructose syrup, pectin and alcohol.

Numerous studies have relevant the therapeutic value of this plant especially attributed to the inulin content which is considered as functional food that offer health benefits beyond their basic nutritional value [15-17]. Inulin and oligofructosans are soluble dietary fibers known to have beneficial nutritional attributes. They act as prebiotics that stimulate the growth of bifidobacteria and lactobacilli but limit the growth of harmful bacteria [18, 19]. Inulin and the other fructosans prevent osteoporosis by increasing the absorption of calcium, magnesium and iron in the intestines, acting on mineralization and bone density. The intake of inulin is also associated with reduction in the risk of some diseases like rheumatism, intestinal infections, constipation, non-insulin dependent diabetes and blood sugar-related illness, obesity and colon cancer. Inulin reduces blood sugar level, reduces levels of triglycerides in the blood and prevents cardiovascular disease by increasing the high density lipoprotein (HLD) to low density lipoprotein (LDL) ratio [1, 16, 20-22]. Another valuable constituent of Jerusalem artichoke is pectin. They reduce the level of cholesterol, improve metabolic processes, normalize bowel movements and improve the peripheral circulation [1, 21].

Jerusalem artichoke is a plant without special requirements, well adapted to the climatic conditions with very good production without special technologies [23]. The tubers can be harvested in the fall or left underground until spring. Postharvest storage of tubers causes quality deterioration, the main causes being dehydration, spoilage, sprouting and depolymerization of reserve carbohydrates [24, 25]. For these reasons, it is recommended to remove from the ground a quantity of tubers that allows a quick processing to avoid storage and implicitly the unfavorable consequences due to damage. The choice of the harvest time must be correlated with the carbohydrate content but also with the productivity of the crop.

The chemical composition that determines the potential use of Jerusalem artichoke is dependent on many factors: variety, stage of harvesting, growing conditions, soil, storage conditions [7-12]. The purpose of this study was to evaluate the effects of harvest time on the soluble solids, reducing sugars and inulin content in tubers of three Jerusalem artichoke cultivars.

2. MATERIALS AND METHODS

2.1. Materials

The research was carried out on the Agricultural Research Development Station Caracal, using three cultivars of Jerusalem artichoke: Dabuleni, Rares and Dacic. Into the experiment we apply the specific technology described in previous published research papers [23]. All cultivars were grown under the same environmental and agricultural conditions. The tubers of studied cultivars were harvested at two stages of biological development (H1 in November and H2 in

March). Representative samples were taken to evaluate soluble solids, reducing sugars and inulin content.

2.2. Analysis methods

Total soluble solids content (%) was determined using a digital refractometer (Kruss Optronic DR 301-95) at 20°C;

The reducing sugars were extracted in distilled water (1:50 w/V), 60 minutes at 60˚C and determined by the colorimetric method at 540 nm with 3,5-dinitrosalicylic acid reagent using glucose as standard [26]. The results were expressed in % fresh weight basis.

Inulin content (%): non-reducing sugars were converting by hydrochloric acid hydrolysis, 25 min at 100°C to reducing sugars. After neutralization, total sugar content (%) was assayed colorimetric with 3,5 dinitrosalicylic acid reagent at 540 nm. Inulin content (% fresh weight basis) is the difference of total soluble sugars (%) and reducing sugars (%) [27].

The spectrophotometric measurements were performed with a Thermo Scientific Evolution 600 UV-Vis spectrophotometer with VISION PRO software. All determinations were performed in triplicate, and all results were calculated as mean.

3. RESULTS AND DISCUSSION

The obtained results show that studied chemical indices vary depending on the analyzed cultivar and the harvest time.

At both harvest times, all cultivars have high soluble solids content (figure 1). At the first harvest time (H1) the values determined vary between 22.3 % (Dacic) and 29.2% (Dabuleni). For all spring harvested cultivars the determined values for soluble solids content are lower than those determined in November, being in the range of 17.9% (Rares) and 22.8% (Dabuleni). The obtained results are similar to data reported in the scientific literature [24, 28].

Soluble solids content is an important index that provides information about the degree of sweetness of fruits and vegetables, helping to determine the maturity of the fruits and the time of harvest.

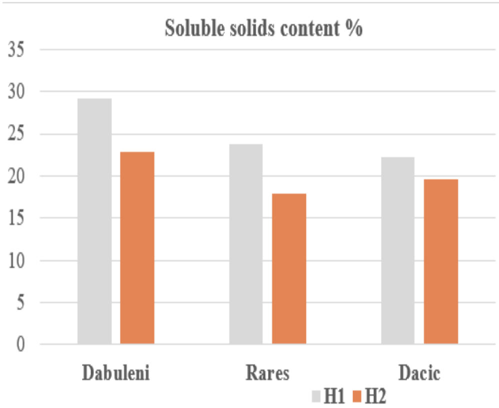

Figure 1. Soluble solids content in tubers of studied cultivars

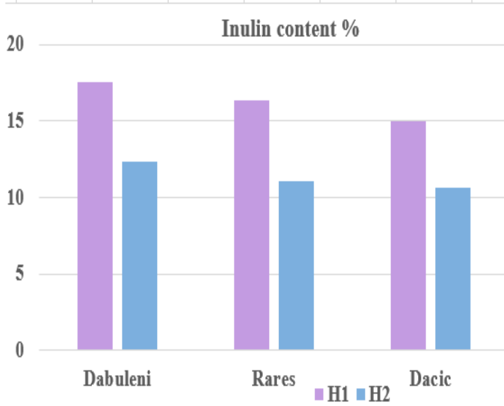

Figure 2. Inulin content in tubers of studied cultivars

All cultivars have a high content of inulin (figure 2). At the first harvest time the content varies between 15.08% (Dacic) and 17.43% (Dabuleni). In March the inulin content decreases to values between 10.61% (Dacic) and 12.37% (Dabuleni). This variation can be explained by the biochemical and physiological processes that take place during the winter and that use carbohydrates as a carbon source.

At the second harvest time all cultivars present appreciable amounts of inulin, making the harvest suitable for multiple uses. The analytical method used in this study does not give information about the structure of inulin, respectively about the degree of polymerization of carbohydrates, which has a great impact on the potential of use. Short-chain fructose which are sweet, with a high fructose content, are used in food and to obtain chemical compounds through fermentation. Chains with a high degree of polymerization that have a low percentage of glucose are used to obtain fructose syrup. For the bioethanol industry they must be enzymatically hydrolyzed and then fermented with different yeasts.

The reducing sugars content varies with the investigated cultivar and harvest time (figure 3). At the first harvest time the values determined vary between 0.185% % (Rares) and 0.253 % (Dacic). At the second harvest time there is an increase in the values that are in the range of

0.231 % (Rares) and 0.308% (Dacic). The increase recorded is between 21.73% (Dacic) and 27.08% (Dabuleni). At both stages of maturity the cultivar Dacic stands out with the highest content of reducing sugars.

The results obtained for the variation of carbohydrates with the harvest time are similar to those reported in other scientific papers. In a study that investigates the qualitative and quantitative development of carbohydrate reserves during the biological cycle the authors show that the tubers lose a fraction of their carbohydrates in winter [9]. The loss results from a biological mechanism necessary for tuber subsistence. The content of fructosans decreases whereas that of simple carbohydrates increases at the end of tuber development [9].

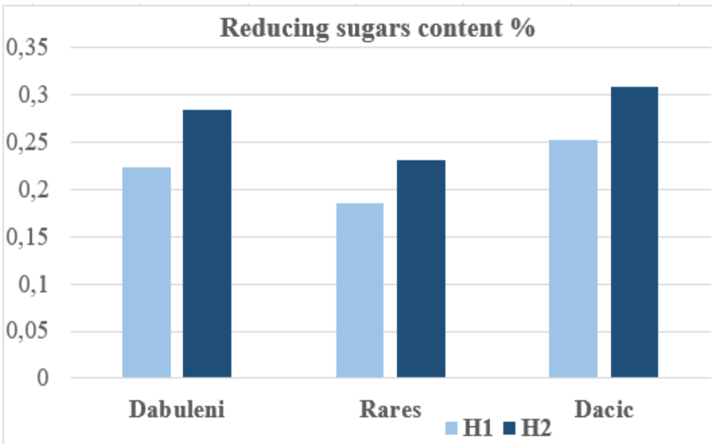

Figure 3. Reducing sugars content in tubers of studied cultivars

Carbohydrates pattern changed during the biological cycle of the tubers, the highest content of polyfructosans being found from early winter. During the winter the fraction of carbohydrates with high molecular mass decreases, the depolymerization of inulin takes place and increases the fraction of reducing carbohydrates and carbohydrates with lower polymerization level [29]. The variation in carbohydrate composition during winter is the effect of inulin hydrolysis under the action of the fructan exohydrolase enzyme.

4. CONCLUSION

The results showed that the tubers of the experimented Jerusalem artichoke cultivars present appreciable content of soluble solids and inulin at both harvest times.

In all investigated cultivars tubers harvested in spring have lower content of inulin and soluble solids and higher content of reducing sugars than those harvested in autumn.

The obtained data recommends soluble solids content as a useful indicator for choosing the cultivar that accumulates the highest amount of carbohydrates and for choosing the optimal time for harvesting.

The choice of the harvest time must be correlated with the carbohydrate content but also with the productivity of the crop.

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