PHYSICO-CHEMICAL AND HEALTH PROMOTING PROPERTIES OF DRIED JERUSALEM ARTICHOKE POWDER

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Abstract: The present study aimed to evaluate the effect of Jerusalem artichoke processing methods and drying methods (freeze drying, sublimation drying, vacuum drying) on the basic physicochemical parameters, profiles and contents of sugars and polyphenolic compounds, and health-promoting properties (antioxidant activity, inhibition of the activities of α-amylase, α-glucosidase, and pancreatic lipase) of the produced powder. A total of 25 polyphenolic compounds belonging to hydroxycinnamic phenolic acids (LC-PDA-MS-QTof) were detected in Jerusalem artichoke powder. Their average content in the raw material was at 820 mg/100 g dm (UPLC-PDA-FL) and was 2.7 times higher than in the cooked material. The chemical composition and the health-promoting value of the powders were affected by the drying method, with the most beneficial values of the evaluated parameters obtained upon freeze drying. Vacuum drying could offer an alternative to freeze drying, as both methods ensured relatively comparable values of the assessed parameters.

Keywords: freeze drying; vacuum drying; sublimation drying; drying time; pro-healthy properties.

Introduction. The Jerusalem artichoke (Helianthus tuberosus; (JA)) is a species of sunflower from the genus Helianthus, belonging to the family Asteraceae, and derived from the North America. In Europe, it has been cultivated since the 17th century. It is characterized by a fast growth rate, is tolerant to droughts, salinity, and frost, and is resistant to diseases and pests. Due to its valuable chemical composition and scientifically proven healthpromoting properties, JA has spurred a growing interest as an edible plant. Its tubers contain ca. 80% of water, 2% of protein, and ca. 20% of carbohydrates, ca. 90% of which are represented by inulin. JA is also valuable considering its bioactive compounds, such as, e.g., polyphenolic compounds, including phenolic acids, which exhibit strong antioxidant properties, and has also been confirmed to elicit antiviral, antibacterial, antiinflammatory, and anti-carcinogenic effects. In turn, as a prebiotic and soluble dietary fiber, inulin contained in JA tubers and stalks (considered to be its richest sources) ensures a hypoglycemic effect in diabetes treatment. In the gastrointestinal tract, inulin undergoes fermentation by the gut microbiota, affecting the state of eubiosis. In addition, it contributes to the increased availability of such minerals as Fe, Mg, and Ca, and influences lipid metabolism. Furthermore, JA improves immunity and concentration, alleviates stress, and eliminates toxic metabolites from the body. Its main applications include production of inulin, feedstuff, fructose syrup, flour, French fries, biochemical materials, and bioethanol. JA tubers processed with various cooking methods were evaluated for their sensory profiles. Thus, taking into account their beneficial effects of providing valuable substances, it is necessary to develop a product with the lowest possible losses of these valuable substances and high storage stability.

Considering the above, we proposed JA powder preserved with a properly selected drying method. The use of the drying process will enable the preservation of the product, making it available all year round, and not only in the maturity period. The most common drying method is convective drying due to its low cost and relatively high efficiency. In turn, sublimation drying (SD) requires high temperatures, is relatively long, which in turn leads to large losses of compounds valuable to the human body, resulting from the high access of oxygen. On the other hand, freeze drying (FD) is the best method to obtain products with the lowest thermal degradation of bioactive compounds during water removal; however, it is relatively costly. Hence, vacuum drying (VD) can be an alternative to SD because it offers a shorter drying time, due to the reduced pressure, and heat supply by conduction. In addition, it allows temperature control, which can reduce the thermal degradation of thermolabile compounds, such as polyphenolic compounds, and is relatively economical. However, different drying processes can affect the quality and induce different positive or negative changes in the finished product. Therefore, it is important to monitor these changes depending on the product being dried. Furthermore, the impact of the technological treatment and changes induced by drying on the content of inulin and polyphenols, and health-promoting values in the innovative dried powder from JA (raw and cooked tubers) has not been studied so far. Considering the above, the present study aimed to evaluate the effect of Jerusalem artichoke processing and drying methods (freeze drying, sublimation drying, vacuum drying) based on the analysis of physicochemical parameters, profiles and contents of sugars and polyphenolic compounds, and health-promoting properties (antioxidant, anti-diabetic, and anti-obesity activity) of the produced powder.

Basic Chemical Parameters The results of analyses of six variants of dry powder obtained from fresh and cooked JA are presented in Table. Both the drying methods and the powder preparation technology statistically significantly affected the ash and pectin contents, while they had no significant effect on the dry matter content, total acidity, and pH ($p < 0.05$). The FD products showed a higher content of dry matter, ash, and pectins. In turn, the lowest contents of pectin, ash, and dry matter were obtained in the products after SD. Therefore, this method was proved the most advantageous for the preparation of the innovative dried JA powder; however, due to its high costs, the VD can be used as an alternative. Taking into account the JA preparation technology, the greatest differences were noted in SD products, where the contents of dry matter and ash were 5% and 9% higher in the powder prepared from cooked JA, while pectin content was 41% higher in the powder made of fresh material. In the case of pectins, after VD and FD, their content was 12% and 28% lower in the powder made from the cooked material than from the raw one. This is because cooking causes plant tissues to break down into individual cells and pectins to leach out. This phenomenon is also characteristic of potatoes and JA, but it is not observed when cooking root vegetables due to their thicker and harder cell membranes.

The results of analyzes of powder and dried JA.

Type of Analysis	**FDC**	**FDR**	**SDC**	**SDR**	**VDC**	**VDR**
Dry matter (g/100 g)	98.88 ± 0.20 a[a]	98.88 ± 0.20 a	97.14 ± 0.19 b	92.66 ± 0.19 e	95.90 ± 0.19 c	95.60 ± 0.19 d
Water activity (a_w)	0.01 ± 0.00 c	0.02 ± 0.00 c	0.15 ± 0.00 c	0.36 ± 0.00 a	0.19 ± 0.00 ab	0.11 ± 0.00 c
Ash (g/100 g)	4.28 ± 0.01 a	4.18 ± 0.01 a	4.10 ± 0.01 b	3.74 ± 0.01 c	3.88 ± 0.01 c	4.16 ± 0.01 b
pH	5.86 ± 0.01 ab	5.83 ± 0.01 ab	5.77 ± 0.01 ab	5.68 ± 0.01 b	5.80 ± 0.01 ab	5.90 ± 0.01 a
Total acidity (g/100 g)	1.08 ± 0.00 a	1.09 ± 0.00 a	1.07 ± 0.00 a	1.06 ± 0.00 a	1.09 ± 0.00 a	1.04 ± 0.00 a
Pectins (g/100 g)	3.10 ± 0.01 d	4.33 ± 0.01 a	1.44 ± 0.00 f	2.46 ± 0.01 e	3.60 ± 0.01 c	4.09 ± 0.01 b
Inulin (g/100 g)	40.08 ± 0.08 e	43.32 ± 0.09 a	43.06 ± 0.09 b	41.22 ± 0.08 c	40.94 ± 0.08 d	38.94 ± 0.08 f
Fructose (g/100 g)	0.10 ± 0.00 b	0.14 ± 0.00 b	0.12 ± 0.00 b	0.40 ± 0.00 a	0.09 ± 0.00 b	0.40 ± 0.00 a
Sucrose (g/100 g)	1.33 ± 0.00 d	1.84 ± 0.00 b	1.23 ± 0.00 d	1.61 ± 0.00 c	1.55 ± 0.00 c	2.06 ± 0.00 a

[a] Values are means ± standard deviation, n = 3. Mean values within a row with different letters as a, b, c, d, e, f are significantly different at $p < 0.05$. Abbreviations: FDC, freeze drying of cooked material; FDR, freeze drying of raw material; SDC,

sublimation drying of cooked material; SDR, freeze drying of raw material; VDC, vacuum drying of cooked material; VDR, vacuum drying of raw material.

The dried powder were found to differ significantly in their color parameters as affected by both the technological treatment and drying method. The best in terms of brightest turned out to be the dried powder prepared from raw JA after FD compared to that made of boiled JA. In contrast, the use of VD and SD for product preservation caused 5% and 9% darkening of the powder made of the raw tubers and 5% and 4% darkening of the powder made of the cooked tubers. The a * and b * color parameters of the tested material indicated that JA cooking intensified the green color and darkened the yellow color of the powder, while powder made of the raw material were more yellow with a slight hue of green. Similar dependencies were observed in the measurements of the a* and b* color parameters depending on the drying method used; the FD powder were characterized by a light hue of green and a dark hue of yellow. An opposite tendency was noted in SD products, revealing a darker hue of green and a lighter hue of yellow. The results obtained for the powder after FD were comparable with the color measurement results reported by Antal et al. for JA subjected to FD drying only. Those demonstrated a similar dependency; namely that the color of the dried material depended on the drying method used, and thus the brightest products were also obtained after FD . The evaluation of the dried powder in terms of water activity (aw) showed statistically significant differences caused by both the drying method and the method of powder preparation (Table 1). The lowest aw, reaching 0.012 for FDC and 0.015 for FDR, was determined for the FD powder, and this value was on average 18 and 11 times lower compared to SD and VD powder, respectively. On the other hand, the aw value determined after VD was two times lower compared to the value determined after SD. The aw value recorded for freeze-dried JA without technological treatment was seven times higher compared to our study. A lower aw value of dried fruits of Saskatoon berry was also noted after FD, whereas there was a higher value after SD. In turn, regardless of the drying method used, the powder made of raw material were characterized by an on average 40% higher aw value. This can be explained by the slight evaporation of water during the cooking process of. However, regardless of the drying method and preparation technology used, the aw of all dried powder was below the critical level (aw = 0.60). This means that they meet the requirement of a product safe from microbiological spoilage, i.e., from contamination with bacteria and mold, because the aw value above 0.60 may cause microbiological spoilage of the finished product.

Conclusions. The analyses of the content of polyphenolic compounds and the health-promoting activity of selected powder variants showed that the best results were obtained in JA dried with FD. It has been proved that not only the drying method but also the type of raw material used for drying played a significant role in modulating the antioxidant, antidiabetic, and anti-obesity properties of the tested material. Hence, much better effects regarding the contents of pectin and health-promoting compounds as well as modeling health-promoting properties were obtained by drying the raw rather than the previously cooked material. The best effects of preserving the natural light color after production were obtained in the freeze-dried samples; however, due to the high costs of this method, it can be replaced by vacuum drying.

References.

1. Amarowicz, R.; Cwalina-Ambroziak, B.; Janiak, M.A.; Bogucka, B. Effect of N Fertilization on the Content of Phenolic Compounds in Jerusalem artichoke (Helianthus tuberosus L.) Tubers and Their Antioxidant Capacity. Agronomy 2020, 10, 1215.
2. Antal, T.; Tarek, M.; Tarek-Tilistyák, J.; Kerekes, B. Comparative effects of three different drying methods on drying kinetics and quality of J.A. (Helianthus tuberosus L.). J. Food Process. Preserv. 2017, 41, e12971.
3. Yang, L.; He, Q.S.; Corscadden, K.; Udenigwe, C.C. The prospects of Jerusalem artichoke in functional food ingredients and bioenergy production. Biotechnol. Rep. 2015, 5, 77–88.
4. Cieslik, E.; Gebusia, A. Jerusalem artichoke (Helianthus tuberosus L.)—Tuber with pro-healthily nutritive properties. Post˛epy Nauk. Rol. 2010, 62, 91. 5. Koroleva, O.; Torkova, A.; Nikolaev, I.; Khrameeva, E.; Fedorova, T.; Tsentalovich, M.; Amarowicz, R. Evaluation of the antiradical properties of phenolic acids. Int. J. Mol. Sci. 2014, 15, 16351–16380.
6. Fotschki, B.; Jurgonski, A.; Fotschki, J.; Majewski, M.; Ognik, K.; Juskiewicz, J. Dietary chicory inulin-rich meal exerts greater healing effects than fructooligosaccharide preparation in rats with trinitrobenzenesulfonic acid-induced necrotic colitis. Pol. J. Food Nutr. Sci. 2019, 69, 147–155.
7. Kalyani Nair, K.; Kharb, S.; Thompkinson, D.K. Inulin dietary fiber with functional and health attributes—A review. Food Rev. Int. 2010, 26, 189–203.
8. Lee, Y.J.; Lee, M.G.; Yu, S.Y.; Yoon, W.B.; Lee, O.H. Changes in physicochemical characteristics and antioxidant activities of Jerusalem artichoke tea infusions resulting from different production processes. Food Sci. Biotechnol. 2014, 23, 1885–1892.
9. Narziyev, M.S; Beshimov, M.X. Theoretical Foundations and Analysis of the Jerusalem Tubers. Texas Journal of Engineering and Technology. 2022, 05, 30, 168-173
10. Narziyev, M.S; Beshimov, M.X. A mathematical model of the drying plate. Zamonaviy mashinasozlikda innovatsion texnologiyalarni qo’llashning ilmiy asoslari: tajriba va istiqbollar. 2022, 23, 09, 491-494