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Improvement of Chips Quality Using Jerusalem Artichoke (*Helianthus tuberosus*) Tubers as a source of Inulin

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INULIN is best found in the tubers of Jerusalem artichokes (JAT) (*Helianthus tuberosus*). Inulin has useful, nutritive, and functional traits. JAT was identified based on its chemical analysis, mineral content, and inulin concentration. In addition, inulin extracted from JAT was determined to have certain physiochemical properties. The sensory characteristics, qualitative characteristics, mineral content, and quality characteristics of chips with adding various levels of JAT (3, 6 and 9%) were evaluated. The JAT included 91.72% moisture, 9.09% protein, and 5.13% ash. The JAT-produced powders were a rich source of K, Ca, Mg, Fe, and P minerals. The optimum sample to solvent ratio for recovering the greatest amount of inulin (73.82%) was 1 g of sample to 9 mL of water at 540 W for 7 min. In addition, the sensory evaluation of the 3 and 6% JAT-enriched chips revealed excellent features. The amount of moisture and salt in the chips prepared by adding JAT was lower than that of the control chips. Finally, chips prepared with JAT might be a beneficial ingredient that could be added to food products, particularly chips, to boost their nutritional value and act as a sweetener for diabetic products, particularly those marketed to children.

Keywords: Functional food; children diabetes; nutrients; sensory characteristic.

1. Introduction

Helianthus tuberosus, often known as "Jerusalem artichoke," "dirt apple," "pig turnip," "guli," or "potato of the poor" (from Hungarian), is a member of the Asteraceae family and, like the sunflower, belongs to the genus Helianthus. The name Jerusalem artichoke, which originates from the Native American tribe "Topinambas," refers to this plant's native region of eastern North America (**Marian *et al.*, 2014**). Although it has a long history of cultivation, the Jerusalem artichoke (*Helianthus tuberosus* L.), is still not widely known. The Jerusalem artichoke has been cultivated for millennia as both a human food source and an animal feed (**Ben Chekroun *et al.*, 1996**).

The tubers of the Jerusalem artichoke have nearly no lipids, no starch, and few calories. According to reports on the lipid content of Jerusalem artichokes, the tubers only have minimal levels of monounsaturated and polyunsaturated fatty acids, and no saturated fatty acids. Because they contain inulin rather than starch, tubers are known as a food source that promotes health and is used as a source of biomass (**Marx *et al.*, 1997**).

The Jerusalem artichoke seems to be a superfood that enhances human digestive, dermatological, and gastrointestinal health. Due to its high inulin content and low carbohydrate level, it is appropriate for people with diabetes and can be included in a balanced hypocaloric diet. The truth is that studies demonstrate that 5 to 15 g per day is beneficial and has a prebiotic effect. Regrettably, its consumption or growth location is unknown (**Mendez-Yánez *et al.*, 2022**).

The Jerusalem artichoke grows tubers notable for their high protein levels, inulin, and minerals (such as potassium, calcium, magnesium, and iron). Sugar is substituted for inulin in a diabetic's diet without harming blood sugar levels. In addition, regular consumption of Jerusalem artichoke tubers helps avoid type 2 diabetes. The functional element obtained from Jerusalem artichoke tubers is used to

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sweeten items for people with diabetes and bolster meals (**Catană *et al.,* 2018**). The tubers of the Jerusalem artichoke are another important component utilized in the production of inulin syrups. Inulin, a fructose-based polysaccharide, is a low-calorie sweetener and culinary ingredient (**Glibowski and Wasko, 2008**). Moreover, inulin, oligo-fructose, and fructose are naturally beneficial dietary elements in Jerusalem artichoke. These nutrients are especially beneficial for those who have type 2 diabetes and obesity since they have both nutritional and functional properties (**Yang *et al.,* 2015).**

The fructose polymer inulin and its decomposition byproduct, oligo-fructose, are essential molecules of interest in the food industry because they are low-calorie and functional food ingredients. Diabetes prevention and anti-carcinoma effects are examples of health-promoting results. In addition, inulin is a type of carbohydrate that is also found in foods for people with diabetes since it has a less dramatic impact on blood sugar levels than other carbohydrates (**Pan *et al.,* 2009).**

Inulin content is crucial because it enhances lipid homeostasis, mineral bioavailability, blood glucose attenuation, rheological features, technological quality, and nutritional values of food products (**Filipović *et al.,* 2013**). Inulin has been characterized as a dietary fiber because the small intestine does not digest or absorb it. Therefore, it serves as a healthy food ingredient, a fat substitute, and an alternative to low-calorie sweeteners. In addition to these beneficial properties, inulin has prebiotic actions that promote the growth and activity of beneficial intestinal bacteria in the human colon (**Gunnarsson *et al.,* 2014**). Furthermore, adding inulin altered the internal structure, as scanning electron microscopy showed. The enriched samples had lower swelling indices, longer cooking times, and higher cooking loss values, primarily due to inulin leaching into the cooking water (**Difonzo *et al.,* 2022**).

Jerusalem artichoke tuber powder is easier to utilize in technical procedures and more convenient to store for longer. Jerusalem artichoke powder has less moisture, protein, and lipid than premium wheat flour but more nutritional fiber, carbs, vitamins, and minerals. Furthermore, the cake could be made using whole Jerusalem artichoke tuber powder with a high inulin content instead of grain flour. Food selection is a complicated process impacted by both non-sensory and sensory aspects, including physiological qualities, familiarity, expectations, attitudes, and health claims (**Prescott *et al.,* 2002**). Jerusalem artichoke flour has a high content of the essential amino acids histidine, isoleucine, methionine, phenylalanine, and valine and a high dry matter content. In order to create a product with improved macronutrient and micronutrient content, greater organoleptic qualities, and longer shelf life, all of which are good for human health, the ideal replacement amount was 5% of wheat flour for Jerusalem artichoke flour (**Chirsanova *et al.,* 2021**).

The current study's objective was to assess the nutritional value of JAT and chips prepared with adding different levels (3, 6 and 9%) of JAT as healthy food, particularly for children.

2. Materials and Methods:

Materials:

Jerusalem artichoke tubers (JAT) were harvested in the winter (January 2021) at the Agricultural Research Centre in Giza, Egypt. The Jerusalem artichoke (white variety) samples were free of physical deterioration, insect harm, and fungi infection.

Methods:

1. Preparation of Jerusalem artichoke tubers (JAT)

Under running water, clean, fresh Jerusalem artichoke tubers (JAT) was washed and cleaned. For thermal treatment, tubers were boiled in a steam cooker (BKK-2175, Beko, Turkey) for 20 min. tubers underwent a second rinse with running water. After cooling, tubers were peeled and crushed in a blender (Robokit 2154, BEKO, Turkey) for two minutes at maximum speed. Finally, JAT was kept at 4°C in sealed bags **(Massoud *et al.,* 2009)**.

2. Determination of the moisture content of Jerusalem artichoke tubers (JAT)

A standard gravimetric technique was employed to measure the moisture content. JAT were weighed in a petri dish using an electronic balance (EW-1500-2M, Kern, Germany) with a sensitivity of 1/1000 g. Next, the sample was put into the ST 055 oven at Simsek Laborteknik, until a constant weight was reached. Finally, the sample's moisture content was estimated using its dry weight **(AOAC., 2010)**.

3. Chemical composition of Jerusalem artichoke tubers (JAT):

The samples' gross chemical composition (ether extract, crude protein, crude fiber and ash content) was determined according to the **AOAC., (2010)** methods. In addition, the available carbohydrate content of samples was calculated by difference:

100- (fat + protein + ash + crude fibre).

4. Determination of the minerals content of Jerusalem artichoke tubers (JAT):

Jerusalem artichoke tubers (JAT) and chips products were mineralized by calcination with the addition of hydrogen peroxide and hydrochloric acid in order to identify the minerals. Atomic absorption spectrometer measurements (type A Analyst 400, Perkin-Elmer) were made for the minerals copper (Cu), manganese (Mn), calcium (Ca), and magnesium (Mg). Flame photometer was used to measure sodium (Na) and potassium (K). Graphite Furnace Atomic Absorption Spectrophotometer (type A Analyst 600, Perkin-Elmer) was used to measure iron (Fe). Using spectrophotometry, phosphorus (P) was identified **(AOAC., 2010)**.

5. Inulin extraction from Jerusalem artichoke using the microwave method

Inulin was extracted from JAT according to **Temkov *et al.* (2015**). Using distilled water as the solvent and three sample-to-water ratios (1:3, 1:6, and 1:9), inulin was extracted using a microwave (LG MB4047C) at 540W. This extraction process was carried out twice. After mixing the filtrates from the two extractions' combined slurry and filtering it, the pH was raised to 8.0 by adding 2% $Ca(OH)_2$. The slurry was centrifuged using a Centrifuge MPW-260R for ten minutes at 3000 rpm, and the supernatant was then neutralized to pH 7.0 using diluted H_2SO_4. Finally, acetone was added to the concentrated solution to precipitate it, and it was then allowed to cool at 7℃.

6. Physiochemical properties of inulin extracted from Jerusalem artichoke tubers (JAT):

6.1 Water holding and oil holding capacities:

A technique adapted from **Glibowski and Bukowska (2011)** was used to measure the oil-holding capacity of inulin. In a 50 mL centrifuge tube, 4 g of JAT powder was combined with 10 mL of distilled water or corn oil. After stirring the mixture for 30 seconds every 5 min, the tubes were centrifuged at 1600 rpm for 20 min. After decanting the free oil, the amount of absorbed oil was calculated using the differential. The amount of water that one gram of sample might hold regarding the water-holding capacity. Oil absorption per gram of sample expressed the oil holding capability.

6.2 Determination of pH

The pH values of the inulin sample were measured using a pH meter (model Cyber Scan 500) according to **Abou-Arab *et al.* (2011).**

7. Technological application:

7.1 Chips preparation

In order to make chips, in Egypt Foods Groups Company for Food Industries, Qwesna City, Menofya Governorate, Egypt. It was combined with 2% (wet basis) Xanthan gum. Two mM thick chips were formed and cooked in a deep fat fryer (HMT 872 L, Bosch, Germany) for 120s at 160°C. After frying, JAT powder was added at different levels (3, 6 and 9%) with chips flavor. Then, the samples were taken on a dry towel and analyzed **(Baltacioğlu, 2012)**.

7.2 Sensory evaluation of chips prepared with adding different levels of JAT:

A twenty-member trained panel (staff members) from the Food Science program at Kafrelsheikh University (aged 30- 45 years old) evaluated the prepared chips with JAT at levels 3, 6, and 9%. The samples were put into paper plate coded-3-digit numbers. One hour after the samples had been made, the sensory evaluation was done. The panelists assessed the chips samples using a 9-pionts-hedonic scale approach for color, taste, odor, texture, appearance, and overall acceptability **(Laignier *et al.*, 2022**).

7.3. Physiochemical properties of chips prepared with adding different levels of JAT

7.3.1. Determination of moisture and salt:

Five grams of each sample of chips were weighed separately and placed in drying bottles. The samples in these bottles were dried in an oven set at 105°C for roughly 24 hours until they reached consistent weight. Then, the bottles were removed from the oven, put in the desiccator, and allowed to cool to room temperature. For salt determination, 5 g of each sample of chips was combined with 200 mL of distilled water, a few drops of 5% K_2CrO_4 indicator were added, and the titration ($AgNO_3$) was stopped when the tile color appeared **(AOAC, 2010)**.

Salt amount%＝［V×N×mEq×F /Sample］×100

Where: V is the amount of $AgNO_3$ spent (mL), N is the normality of $AgNO_3$ solution（0.1N）, F is the factor of $AgNO_3$ solution, mEq is the equivalent weight of the spindle to NaCl（0.058 g), and sample means the sample amount (g).

7.3.2. Determination of acidity:

The chips sample (5 g) was broken, weighed, and filled with 50 mL of hexane. It was left in the dark for 24 h before the hexane was evaporated in an oven for 12 h at 105±2°C. One gram of the samples was taken, diluted in 10 mL of diethyl ether: ethanol (1:1, v/v), and titrated with 0.1 N NaOH by adding a few drops of phenolphthalein indicator. When a persistent violet-purple color was seen using wasted NaOH (V) in mL, titration was stopped following the following expression **(AOAC, 2010**).

Acidity % ＝V ×2.82 / sample weight.

Where: V is the amount of NaOH (mL).

7.3.3. Determination of peroxide value

A 5 g chips sample was crushed, 50 mL of hexane was added, and left in the dark for 24 h. After that, the hexane was evaporated using filter paper in an oven set to 105°C for 12 h. Next, one g of the oil samples was extracted, dissolved in 10 mL of chloroform, and combined with 15 mL of acetic acid. After adding 1 mL of saturated KI solution, 10 min were spent in the dark. Afterward, 75 mL of pure water and 1 mL of a starch solution were dropped, and amount consumption was measured using 0.002 N sodium thiosulfate **(AOAC, 2010).**

Peroxide value (meq O_2/kg oil) ＝ 2×amount of sodium thiosulfate (ml) /sample weight (g)

8. Statistical analysis

Three samples were analyzed for each treatment, whereas all assays were carried out in triplicate. Results were expressed as mean values and standard deviations (SD) and analyzed using one-way analysis of variance (ANOVA) at $p \leq 0.05$. This analysis used SPSS v. 23.0 program (IBM Corp., Armonk, NY, USA) **(Steel, *et al.*, 1996**).

3. Results and Discussions

1. Chemical composition of Jerusalem artichoke tubers (JAT):

Table (1) revealed the proximate chemical composition of the powders made from JAT. The nutritional value of JAT was 91.72% moisture, 9.09% protein, 2.05% fat, 7.63 % fibre, and 5.13% ash. These results are comparable to those reported by **Izembaeva *et al*. (2013)** were moisture (92.2%), fat (1.66%) and ash (6.91%), but the protein level was higher (9.93%). This slight difference with other researchers may be due to the type of JAT variety and cultivation conditions and soil conditions.

2. Minerals content of Jerusalem artichoke tubers

The mineral contents are displayed in **Table (2)**. Powder made from JAT has a high mineral content. The powders made from JAT have a very high potassium concentration (26600 mg/kg) However, a meta-analysis of randomized controlled trials conducted by **Poorolajal *et al.* (2017)** whom revealed that potassium supplementation is a safe medication with minimal but significant blood pressure-lowering effects and may be suggested as an adjuvant antihypertensive agent for patients with essential hypertension. Due to its high potassium content, Jerusalem artichoke powder can be a significant component of a high blood pressure patient's diet. The powder of Jerusalem artichoke contains a significant amount of phosphorus (1293 mg/kg). The amount of phosphorus in the human body ranges from 560 to 850 g, or 0.8% to 1.2% of total body weight. Phosphorus is the second most common mineral in the human body, behind calcium (**Gropper and Smith, 2013**). Also, this slight difference with others researchers may be due to the type of JAT variety and conditions of cultivation and soil. In addition, the mineral contents of powder achieved from JAT-Red variety is higher than that recorded for the powder obtained from the JAT-White variety processing.

Table 1. Proximate chemical composition (% on dry weight) of JAT powder.

Sample	**Moisture**	**Crude Protein**	**Ether extract**	**Ash**	**Crud Fibre**	**Available carbohydrates**
JAT	91.72±0.61	9.09±0.11	2.05±0.09	5.13±0.33	7.63±0.23	76.1±1.3

Each value is an average of three determinations ± standard division.

Table 2. Minerals content (mg/kg) of Jerusalem artichoke tubers (JAT).

Sample	**Na**	**K**	**Ca**	**Fe**	**Cu**	**Mn**	**Mg**	**P**
JAT	720.0±1.7	26600±18.0	729±3.9	38±2.2	54.95±3.0	2.05±0.2	2037±6.2	1293±8.2

Each value is an average of three determinations ± standard division.

3. Inulin content of Jerusalem artichoke tubers (JAT):

Fig. (1) shows the impact of different solvent ratios (water) on the effectiveness of inulin extraction. From the results, it should be noticed that the percentage of extractable inulin (70.3, 72.04, and 73.82%) was increased dramatically with increasing solvent ratio to the sample. The best sample-to-solvent ratio for recovering the maximum yield of inulin was 1 g of sample to 9 ml of water at 540 W. **Elzeny *et al.* (2019)** mentioned that the best way to extract the inulin is to use a microwave powder of 540 W using a sample to the solvent ratio 1 g of sample to 10 mL of water. Using the same extraction conditions, **Hu *et al.* (2007)** compared the effectiveness of inulin extraction from fresh JAT (*Helianthus tuberosus*) powder using conventional and microwave processes. The results showed that the yield of inulin extraction using the microwave method was higher (82.9%) than that of conventional extraction (65.5%). With a noticeably poor extraction yield, inulin was found in the extract's insoluble fraction. Moreover, microwaves heat the entire sample volumetrically, breaking up weak hydrogen bonds and encouraging molecular dipoles to spin. The solubility of the target molecule increases because of the heating effect since it raises the solvent's temperature.

4. Physiochemical properties of inulin extracted from JAT

Results in **Fig. (2**) showed that the mean values of the physicochemical properties, such as water holding capacity, oil holding capacity, and pH, of extracted inulin from Jerusalem artichoke powder were 1.57 g/g 2.93 g/g, and 5.74, respectively. While, commercial inulin (**Mudannayake *et al.*, 2015**) had values of 1.59, 3.47, and 5.98 g/g respectively. These outcomes are consistent with those reported by **Elzeny *et al*. (2019).** This decrease in physical properties of extracted inulin than the physical properties of commercial inulin maybe this is due to the purity level of extracted inulin (89%), in comparison to commercial inulin used as standard, which had a purity of 98.5%.

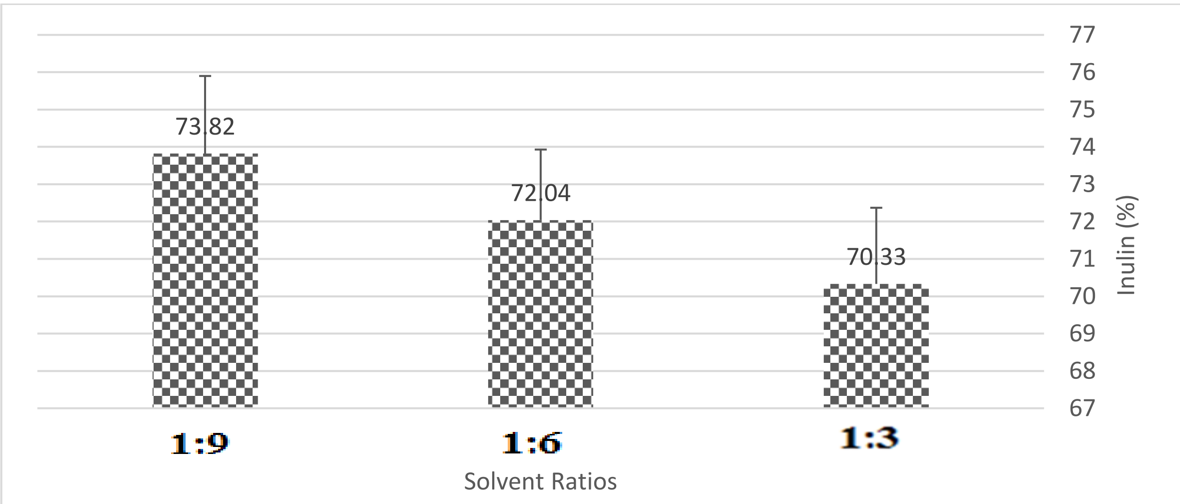

Fig. 1. Inulin content of Jerusalem artichoke tubers (JAT) at different solvent ratios.

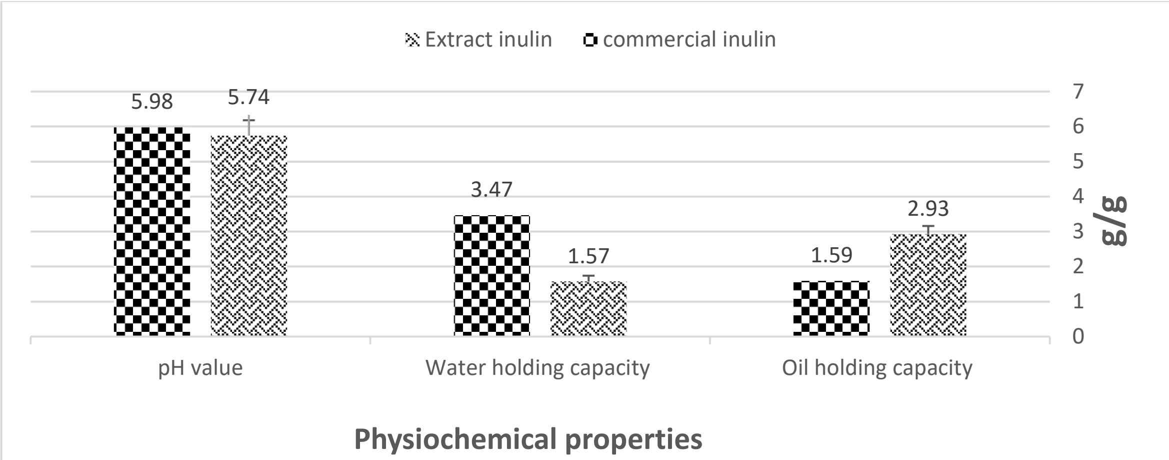

Fig. 2. Physiochemical properties of inulin extracted from Jerusalem artichoke tubers (JAT).

5. Sensory evaluation of chips prepared with adding different levels of JAT:

The sensory evaluations were scored using a ranking test to gauge how well-liked a cuisine is. A higher score indicates that the food is more well-liked. **Table (3)** shows the sensory evaluation of fried Jerusalem artichoke chips. According to the results, the Jerusalem artichoke with a 3% Jerusalem artichoke content received the highest marks for taste and color attributes, (9.7). These ratings somewhat outperformed those of the 6 and 9% Jerusalem artichoke. Level 3 and 6% of Jerusalem artichoke were rated first and second, respectively, in the overall acceptability, according to the results. The sensory evaluation results showed excellent qualities for the chips made by adding 3 and 6% Jerusalem artichoke. Samples of prepared chips with a Jerusalem artichoke content over 10% had lower organoleptic indices, including lower shape and volume, cracked surface, and pronounced flavor. **Difonzo *et al.*, (2022)** mentioned that cooked and raw enriched pasta was much darker and firmer, but the sensory qualities were unaffected, notably at the 5 and 10% substitution levels. In addition, inulin-enriched pasta stimulated prebiotic development after digestion, drastically decreasing the number of E. coli cells.

Table 3. Sensory evaluation of chips prepared by adding different levels of JAT.

Formulations	Color	Taste	Odor	Texture	Appearance	Overall Acceptability
Control	9.6±0.19a	9.7±0.42a	9.1±0.41a	9.4±0.36a	9.5±0.45a	9.4±0.37a
3 %	9.7±0.13a	9.7±0.24a	9.0±0.34a	9.3±0.63a	9.5±0.58a	9.4±0.36a
6%	9.6±0.33a	9.6±0.33a	8.9±0.38a	9.1±0.39ab	9.3±0.69ab	9.3±0.23a
9 %	9.5±0.37ab	9.5±0.52ab	8.7±0.47ab	9.0±0.45b	9.2±0.27b	9.2±0.32ab

Each value was an average of three determinations± standard division .
Values followed by the same letter in columns are not significantly different at $p \leq 0.05$.

6. Physiochemical properties of chips prepared with adding different levels of JAT

Table (4) shows the physiochemical characteristics of chips prepared by adding different levels of JAT. The moisture and salt content of the chips samples are lower than those found in the control chips. The ranges of moisture (0.95 to 0.97%) and salt contents (1.34 to 1.54%) of prepared chips by adding JAT. Also, the homogenous distribution of salt on the slices during sample preparation and the percentage of salt in chips flavors was higher than that of JAT. These findings align with **Ghafoor *et al.* (2020)**, who found that chips' moisture and salt concentrations ranged from 0.49 to 0.88% and 1.30 to 1.75%, respectively.

On the other hand, the levels of acidity and peroxide values in the chips prepared with various amounts of Jerusalem artichoke were greater than in control. Free acidity and peroxide values increased as the fortification level of chips increased. In the food sector, free fatty acids are regarded as a marker of fat quality. Because it imparts a bad taste to fried foods and oils. Peroxides are also changed into these by-products during the degradation process. Consequently, determining it is crucial **(Ghafoor *et al.*, 2020)**.

Table 4. Physiochemical properties of chips prepared with adding different levels of JAT.

Formulation	Moisture (%)	Salt (%)	Acidity (g/L)	Peroxide value (meq O_2/kg of oil)
Control	1.0±0.09a	1.68±0.19a	0.10±0.01b	0.50±0.01b
3 %	0.97±0.04a	1.54±0.13 a	0.15±0.01a	0.57±0.01ab
6%	0.97±0.05a	1.41±0.16ab	0.20±0.03a	0.63±0.03a
9 %	0.95±0.08 b	1.34±0.11b	0.22±0.03a	0.77±0.07a

Each value was an average of three determinations± standard division .
Values followed by the same letter in columns are not significantly different at $p \leq 0.05$.

7. Minerals content of chips prepared with adding different levels of JAT:

Minerals take place in the body. Ca, P, and Mg are necessary for bones to form and remain healthy. Additionally, P and Mg are crucial for energy metabolism, whereas Ca plays a role in blood coagulation. The electrolyte K, along with Ca, P, and Mg, is crucial for maintaining appropriate acid-base balance, osmotic pressure, and water balance, neuronal transmission, muscular activity, vascular constriction, and dilatation. P and Mg function as cofactors or as parts of the enzyme systems in enzymatic processes. P also appears in nucleotides, nucleic acids, and cell membranes **(Saldamlı and Sağlam, 2007).**

Table (5) shows the minerals content in control and chips prepared with Jerusalem artichoke at various levels. Data showed that the levels of calcium, magnesium, potassium, and copper in the control group were 244, 1426, 10072, and 0.30 mg/kg, respectively. Additionally by boosting the levels of Jerusalem artichoke, the mineral content of the prepared chips was increased. These results agree with **Gedrovica and Karklina (2012)** who reported that the supplementation of cakes with Jerusalem artichoke powder increased the amount of K, Mg, P and Ca compared with the control sample.

Table 5. Minerals content (mg/kg) of chips prepared with different levels of JAT.

Formulation	Na	K	Ca	Fe	Mn	Mg	P
Control	4655±12.1	10072±19.1	244±4.3	28±0.33	4.03±0.89	1426±2.1	1067±1.1
3 %	4710±9.7	10490±22.3	311±3.1	31±0.23	4.24±0.78	1560±2.8	1100±2. 7
6%	4866±5.2	10870±11.4	419±2.6	35±0.29	4.78±0.76	1676±3.5	1180±2.0
9 %	4917±7.5	11021±7.8	490±3.9	38±0.32	5.15±0.92	1793±4.1	1204±1.9

Each value was an average of three determinations± standard division .

8. Quality parameters of prepared chips with different levels of JAT

Table (6) evaluated the quality properties of control chips and chips prepared with adding various levels of JAT. Control had 7.35% protein and 45.73% available carbohydrates. In contrast, their higher protein distinguished chips samples with different levels of JAT (3, 6, and 9%) and lower carbohydrate contents, the values of protein were 8.04, 8.27, and 9.29%, respectively, and the values of carbohydrates were 44.13, 42.97 and 41.28%, respectively. Additionally, it should be noticed that as JAT concentration increased, the percentage of protein increased while the percentage of available carbohydrate declined. Fat content in chips including JAT is greater than control chips, whereas fat content in control sample was 33.7%, fat content in chips containing JAT was 33.9, 34.1, and 34.3%, at concentration levels of 3, 6, and 9%, respectively. Furthermore, Jerusalem artichoke chips differed from controls by having a higher ash concentration. These findings are consistent with those found by **Ozgoren *et al.*, (2019)**, who reported that the addition of Jerusalem artichoke caused a significant ($p < 0.05$) increase in ash, protein and fat. While, there are a decrease ($p < 0.05$) in carbohydrates content.

Table 6. Quality parameters of chips prepared with different levels of JAT.

Formulation	Protein	Ash	Fat	Fiber	Available carbohydrates
Control	7.35±0.99 c	9.45±0.12b	33.7±0.51b	3.77±0.31b	45.73±0.14a
3 %	8.04±1.0 b	9.84±0.20b	33.9±0.32 a	4.09±0.25b	44.13±0.11a
6%	8.27±1.1 b	10.11±0.21a	34.1±0.77 a	4.55±0.22a	42.97±0.13b
9 %	9.29±1.0 a	10.33±0.17a	34.3±0.78 a	4.80±0.29a	41.28±0.19b

Each value was an average of three determinations± standard division .
Values followed by the same letter in columns are not significantly different at $p \leq 0.05$.

4. Conclusions

The functional elements, physical characteristics and quality attributes of chips are all enhanced by adding JAT. Since they contain inulin and the tubers of JA are significant suppliers of nutrients. These advantages were more pronounced at 3 and 6% of JAT per serving in chips. In addition, JAT was added to the chips by up to 6%, which further increased their organoleptic qualities. On the other hand, the chips produced in this study have a high quantity of inulin (73.8%), making them ideal for producing chips for people with diabetes. Finally, JAT-based chips can be considered valuable components that can be added to food items, particularly chips, to improve their nutritional content and serve as a sweetener for diabetic products. Jerusalem artichoke flour could be a nutritious factor for baby food and baking ingredients.

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تحسين جودة الشيبسي باستخدام درنات الطرطوفة (*Helianthus tuberosus*) كمصدر للإنيولين

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يوجد الإنيولين بشكل أفضل في درنات الطرطوفة. الإنيولين يحتوي على خواص غذائية ووظيفية مفيدة. تم تقدير التحليل الكيميائي والمحتوى المعدني وتركيز الأنيولين في درنات الطرطوفة. أيضا، تم تحديد الخصائص الطبيعية والكيميائية للإنيولين المستخرج من درنات الطرطوفة. تم تقييم الصفات الحسية والخصائص النوعية والمحتوى المعدني وصفات الجودة للشيبسي المضاف له مستويات مختلفة (٣، ٦ و٩٪) من مسحوق درنات الطرطوفة. تحتوي درنات الطرطوفة على٨٥.٢٥٪ رطوبة و١٥.٩٦٪ بروتين و٤.٢٣٪ رماد. كان مسحوق درنات الطرطوفة مصدرًا غنيًا بمعادن البوتاسيوم، الكاليسوم، الماغنسيوم، الحديد والفوسفور. نسبة العينة المثلى إلى المذيب لاستخلاص أكبر كمية من الأنيولين (٧٣.٨٢٪) هى ١ جم من العينة إلى ٩ مل من الماء في الميكرويف عند ٥٤٠ وات لمدة ٧ دقائق. بالإضافة إلى ذلك، أظهر التقييم الحسي للشيبسي المضاف له بنسبة ٣ و٦٪ خواص جيدة. كانت كمية الرطوبة والملح في الشيبسى المضاف له مسحوق درنات الطرطوفة أقل من تلك الموجودة في عينات الكنترول. في النهاية، الشيبسي المضاف إليه مسحوق درنات الطرطوفة يعتبر مكونًا مفيدًا يمكن إضافته إلى المنتجات الغذائية، وخاصة الشيبسي، لتعزيز قيمتها الغذائية والعمل كبديل لمنتجات مرضى السكري، وخاصة تلك التي يتم تسويقها للأطفال.

الكلمات المفتاحية: الغذاء الوظيفي، سكري الأطفال، المغذيات، الخصائص الحسية.