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# دراسات كيميائية و تكنولوجية علي استبدال دقيق القمح بالطرطوفة في الكيك

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**ملخص البحث:**

نظام الحياة العصرية يساهم فى استهلاك الوجبات الخفيفة بما يقرب من ثلث الطاقة اليومية، حيث نجد أن العديد من الأطعمة تتكون من محتوي عالي في الكربوهيدرات و الطاقة و الدهون ولكنها فقيرة فى محتواها من البروتين والعناصر و التى تتسبب فى الإصابة بحالات السمنة و مرض السكرى. فلذا تهدف هذه الدراسة إلى إضافة درنات الطرطوفة للكيك لتحسين محتواه الغذائي. حيث تم استبدال دقيق القمح بدقيق درنات الطرطوفة بنسب مختلفة (١٠، ٢٠، ٣٠، ٤٠ و٥٠%) و التى تحتوى على نسب عالية من الأنيولين. فهذه الدراسة تدرس تأثير إضافة مسحوق درنات الطرطوفة إلى دقيق الكيك على التركيب الكيميائي للكيك و محتواه من مضادات الأكسدة والخصائص الريولوجية لخلطات الدقيق من حيث (كمية الماء المطلوبة لاتمام العجن وتقدير مرونة العجينة) وأيضا دراسة التقييم الحسي للمنتج النهائي للكيك. وأوضحت النتائج الأتي:

أن إضافة الطرطوفة إلى الكيك أدت لتحسين خصائص الكيك ومحتوياتها من العناصر الغذائية (البروتين، الألياف، الحديد، الزنك والكالسيوم و الفسفور)، ومضادات الأكسدة ومحتواها من ( الفينولات ، الفلافونويدات ). أما بالنسبة للخصائص الحسية فأوضحت النتائج قبول عينات الكيك بصفة عامة و لكن كان هناك انخفاض طفيف في تقييمها الحسي.

**الكلمات المفتاحية :** الطرطوفة، الكيك، التركيب الكيميائي، الخصائص الريولوجية، التقييم الحسي .

# Chemical and Technological Studies on replacement wheat flour by Jerusalem Artichoke *(Helianthus tuberosus)* in cake

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## Abstract:

New lifestyle society, snacking contributes nearly to one-third of daily energy intake. Most of snacks are rich of carbohydrates, high fat and energy which caused to obesity and diabetic statues. Also, this snacks are very poor protein content. So this investigation amid to use the Jerusalem artichoke (*Helianthus tuberosus*) to improve the nutritional content of cake, as replaced wheat flour with Jerusalem artichoke powder in different percentages (١٠, ٢٠, ٣٠, ٤٠ and ٥٠٪) which has a big part of inulin. The current investigation studied the effect of replacement Jerusalem artichoke powder (JAP) to cake on chemical composition, some phytochemical contents, rheological properties (Farinograph and extinsograph), texture analysis and sensory evaluation of product after process. In general addition of Jerusalem artichoke powder to cake improved the properties of cake and nutrients contents (protein, fiber, Fe, Zn, P and Ca), phytochemical contents (total phenols, total flavonoids and antioxidant activity) and cake texture. As well as, all samples of cake generally were acceptable, but control cake had a high significantly difference compared cake with JAP. Also, there was a slight decrease in sensory evaluation.

**Key words:** Jerusalem artichoke (*Helianthus tuberosus*), Cake, Dried, Fresh, Chemical composition, Phytochemical, Minerals, Rheological properties Texture, Sensory evaluation.

## Introduction:

Jerusalem artichoke (*Helianthus tuberosus L.*) is known as the earth apple and it is a species of sunflower **(Voss et al., ٢٠٢١).** Moreover, it is called "Jerusalem sunflower" and "potato sunflower" due to the bright yellow color of flowers, with a flower structure resembling that of the sunflower (**Lv et al., ٢٠١٩ and USDA, ٢٠٢٠**). The tubers of the Jerusalem artichoke are typically irregularly spherical or spindle-shaped and can range in color from pale brown to white, purple or red (**Nabeshima et al., ٢٠٢٠**).

Jerusalem artichoke tubers contained a percentage of protein, dietary fiber and minerals, especially iron, potassium, and phosphorus. Also, contain vitamin C, thiamine and niacin **(Ozgoren, et al., ٢٠١٩)**

Moreover, fresh JA contained water (٧٥–٨٠٪ w/w), and total carbohydrates up to ٢٢٪ of fresh weight, with inulin as ٧٠–٩٠٪ of carbohydrates (**Barkhatova et al., ٢٠١٥**). Soluble carbohydrates and inulin are derivatives fructooligosaccharides and simple sugars such as fructose, glucose, and sucrose **(Rubel et al., ٢٠٢٢).**

Jerusalem artichoke tubers are recognized as a health-promoting food source, primarily because of it contain of inulin instead of starch. Inulin, a polymer of fructose, along with its breakdown product oligofructose, is key compounds in the food industry due to their role as a functional food ingredients and low-calorie options (**Kaur and Gupta, ٢٠٠٢**).

Jerusalem artichoke is rich in nutrient contents especially bioactive compounds (**Wang et al., ٢٠٢٠**). Jerusalem artichoke (JA) has medicinal properties like anti-fungistatic, anti-carcinogenic and antioxidant components (**Sawicka et al., ٢٠٢٠**). So, could be used in the pharmaceutical industry. Also, JA it used in the food industry because has a nutritional and functional properties **(Voss et al., ٢٠٢١).** On the other hand, composition of JA improve cholesterol, triglycerides and high glucose levels (**Downer et al., ٢٠١٤**); facilitates weight loss **(Park, ٢٠١١ and Munim et al., ٢٠١٧)**; detoxes the organism and lowers uric acid levels **(Kronberga et al., ٢٠١٣)**. As well as, it has possesses immunostimulating properties, protects the gastric mucosa, aids in preventing and improving metabolism related to lipid disorders, helps reduce body weight, and exhibits cytotoxic effects against breast cancer **(Horochowska et al., ٢٠١٧**). It also helps in cardiovascular diseases **Saiki et al., (٢٠٢٢) and Sawicka et al., (٢٠٢٠)** chronic infectious diseases, chronic fatigue syndrome, gut flora disorders and immune system disorders. *H. tuberosus* tubers can be effectively decreasing the frequency of respiratory diseases and deny from premature ageing **(Chang and Jia, ٢٠١٤)**. Jerusalem artichoke tubers (JAT) protect the liver and prevent urinary tract infections **(Sobel and Matławska, ٢٠٠٥ and Kronberga et al., ٢٠١٣)**.

Cakes, biscuits and crackers are among the most popular products in the bakery industry (**Kita et al., ٢٠٢٠**). Their popularity can be attributed to several factors, including a wide range of flavors, easy accessibility, convenience as ready-to-eat items, lower prices and long shelf life compared to other processed foods (**Guiné and Florença, ٢٠٢٤**). Cakes are sweet baked products made from cereal ingredients made primarily from wheat flour and known for its elastic structure and specific flexible (**Ammar et al., ٢٠٢٠**) however, it tends to be low in functional components like minerals, fiber and vitamins (**Najjaa et al., ٢٠٢٠**). The Jerusalem artichoke (*Helianthus tuberosus L.*) has been used in the food industry because of its functional properties and appealing nutritional **(Voss et al., ٢٠٢١).** The addition of Jerusalem artichoke powder (JAP) is restricted by technological factors **(Bicāne, ٢٠٠٧)** and the sensory requirements for cakes **(Linden, ١٩٩٥).**

The objective of this study led to formulate functional cake with JAP. Also, study effect of additional JAP technological properties of cake, and chemical properties of cake by partial substitution of wheat flour with JAP.

## Material and methods

### Raw materials

Jerusalem artichoke was purchased from El-Qanater El-Khaireya Station Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.

Ingredients of cake (wheat flour, sugar, corn oil, eggs, vanilla, salt and baking powder) were purchased from local market in Zifta, EL-Gharbiyah Governorate, Egypt.

### Chemicals:

Folin-Ciocalteu phenol reagent (٢N), quercetin dihydrate (٢-(٣,٤-dihydroxyphenyl), gallic acid and the standards and ٢, ٢-Diphenyl-١-picryhydrazyl (DPPH) were purchased from Sigma–Aldrich (St. Louis, MO, USA). Sodium Carbonate (٩٩.٨٪) (NaCo٣, sodium nitrite (NaNO٢), Aluminum chloride (AlCl٣) and sodium hydroxide (NaOH) were punched from Gamma-Tread Company, Cairo, Egypt.

## Methods

### Preparation of Jerusalem artichoke powder

Jerusalem artichoke tubers were cleaned and washed with tap water to remove dirt and impurities. Then, it peeled and cut into slices then the slices were dried in solar energy at the National Research Center (NRC) Dokki, Egypt. The dried Jerusalem artichoke was ground into fine power in an electrical grinder very well and packed in polyethylene bags and kept in the refrigerator at ٤±١ $^{O}$C until use.

## Preparation of Jerusalem artichoke cake

Six samples of cake were prepared as shown in table (١). Jerusalem artichoke powder was replaced with wheat flour by ١٠٪, ٢٠٪, ٣٠٪, ٤٠٪ and ٥٠٪. Formula mixtures were prepared according to the method described by **(Raeker and Jonhnson, ١٩٩٥).**

**Table (١): The ingredients that used in preparation Jerusalem artichoke cake (g)**

| Formulas / Ingredients | Control | ١٠٪ JAP | ٢٠٪ JAP | ٣٠٪ JAP | ٤٠٪ JAP | ٥٠٪ JAP |
|---|---|---|---|---|---|---|
| Jerusalem artichoke powder ( JAP) | ٠.٠ | ١٠ | ٢٠ | ٣٠ | ٤٠ | ٥٠ |
| Wheat flour extraction (٧٢٪) | ١٠٠ | ٩٠ | ٨٠ | ٧٠ | ٦٠ | ٥٠ |
| Corn oil | ٥٠ | ٥٠ | ٥٠ | ٥٠ | ٥٠ | ٥٠ |
| Sugar | ٦٠ | ٦٠ | ٦٠ | ٦٠ | ٦٠ | ٦٠ |
| Eggs | ٥٠ | ٥٠ | ٥٠ | ٥٠ | ٥٠ | ٥٠ |
| Baking powder | ٥ | ٥ | ٥ | ٥ | ٥ | ٥ |
| Vanilla | ١ | ١ | ١ | ١ | ١ | ١ |
| Salt | ١ | ١ | ١ | ١ | ١ | ١ |

## Chemical analysis

Moisture, protein, total lipids, crude fiber, ash, were determined for fresh and dried JA and JAP cake according to the **(A.O.A.C, ٢٠١٠).** Total carbohydrate was calculated by difference. Energy was calculated according to the **(FAO/WHO/UNU, ١٩٨٥).** Total phenol was determined of samples by Folin Ciocalteau's reagent according to the method described by **(Arnous et al., ٢٠٠١).** The total flavonoid content was determined for samples by aluminum chloride method according to **(Chang et al, ٢٠٠٢).** Antioxidant activity was determined for samples by the ١,١- diphenyl-٢-picryl-hydrazyl (DPPH) method **(Brand-Williams, et al., ١٩٩٥).**

## Determination of inulin

The purity of inulin was determined for fresh and dried JA by subtracting the reducing sugar content from the total sugar content (٣-

amino-٥-nitrosalicylic acid method) as described by the **(A.O.A.C, ٢٠٠٠).**

**Determination of minerals**

Some minerals content (Zinc, Iron, Phosphor and Calcium) were determined of sample using a Pye Unicum SP ١٩٠٠ Atomic Absorption Spectroscopy instrument (Perkin Elmer model ٤١٠٠ ZL) as described by the **(A.O.A.C, ٢٠١٠)** at Soils, Water and Environment Research Institute (SWERI), ARC, Giza, Egypt.

**Rheological evaluation (Farinograph and extinsograph):**
**Farinograph properties**

All flour dough blends were analyzed by using, farinograph apparatus, to determine water absorption (%), arrival time (min), dough development time (min), dough stability (min) and dough weakening (B.U) following the methods described in **(A.A.C.C. ٢٠٠٠).**

**Extensograph tests**

All flour dough blends were evaluated by using extensograph apparatus, to determine dough energy ($cm^{٢}$), dough extensograph (E), (mm), resistance to extension (R) (B.U) and proportional number (R/E) following the methods described in (**A.A.C.C. ٢٠٠٠).**

**Texture profile analysis of cake samples**

Hardness Cycle, Springiness and Gumminess were determined as described by **(Bourne, ٢٠٠٣)**.

**Sensory evaluation of cake samples**

The samples were subjected to evaluate sensory attributes [crust color (١٠), crumb color (٢٠), odor (١٥), texture (١٥), taste (٢٠), grains (٢٠) and overall acceptability (١٠٠)] by ten trained panelists of Food Technology Research Institute (FTRI), Giza, Egypt, according to **(Soliman, ١٩٩٦).**

## Statistical Analysis

Statistical analyses were conducted using the SPSS program (Version ١٩). Data were expressed as means ± SD and the statistical analysis was performed using one way analysis of variance followed by Duncan's tests **(Snedecor and Cochran, ١٩٨٩).**

## Result and discussion

The chemical composition of fresh and dried Jerusalem artichoke is shown in table (٢). Results indicated that fresh sample had the high level in moisture as they ٧٦.٣٣±٠.١ while dried sample recorded high total lipids, protein, ash, fiber, carbohydrate and energy were (٠.١٢±٠.١٠), (١٠.١٣±٠.١٠±), (٥.٥٥±٠,٢٠), (٣.٩٤±٠.٢٠), (٧٧.٥٥±٠.٢١) and (٣٥٢±١.٨٥), respectively. These results are consistent with **El-Kholy and Mahrous (٢٠١٥)** who studied the chemical composition of Jerusalem artichoke tubers were calculated for dried JA. The authors found that Jerusalem artichoke contained a low level of moisture content (٦.٨ ± ٠.١١ g/١٠٠ g), and total carbohydrate content, curd fat, curd protein, ash and curd fiber were almost the same results in this study. Jerusalem artichoke tubers are high in soluble dietary fiber (**Kays and Nottingham, ٢٠٠٧**).

Data presented at the same table (٢) showed that, inulin content in dried sample was higher (٥٨.٠١±٠.٠٦) than that fresh sample (١٣.٩±٠.٠١). The data were agreement with those found by **Barkhatova et al., (٢٠١٥)** who stated that Jerusalem artichoke may become the foundation for establishing large-scale industrial production of inulin. Jerusalem artichoke (*Helianthus tuberosus*) tubers may contain about ٧٠٪ of inulin based on dry weight (**Baldini et al., ٢٠٠٤**). Also the results were agree with **(Rushchitc et al., ٢٠٢٢)** who reported Jerusalem artichoke contain high amount of inulin.

Results in table (٢) showed that, some minerals content (P, Zn, Fe and Ca) in fresh and dried Jerusalem artichoke samples. The results indicated that dried sample had the higher level in (P, Zn, Fe and Ca) then fresh sample. It is evident from the obtained results that P, Zn, Fe and Ca of fresh JAP were (٠.١٨, ٠.٧٦, ١٠.١٤ and ٣٢.٣٦mg/١٠٠gDW), respectively. Meanwhile dried JAP were (٠.٦٢, ٢.٦٢, ١٤.٢٠ and ٨١.٦٠ mg/١٠٠g DW) respectively. These results are in the line with previous studies of **Butin et al., (٢٠٠٦); Harmankaya et al., (٢٠١٢); El-Sohaimy, (٢٠١٤); AboTaleb (٢٠١٨) and Rushchitc et al., (٢٠٢٢)** who reported that, dried Jerusalem artichoke had more than fresh JA in minerals such as (Ca, P, Zn, Fe and Mg) which it's are essential minerals at sufficient levels for human nutrition.

Data presented in table (٢) revealed the phytochemical composition (total phenol, total flavonoids and antioxidant activity (DPPH %)) in fresh and dried Jerusalem artichoke samples. Generally, JA dried had greater than JA fresh for total phenol, total flavonoids and antioxidant activity (DPPH); (٣٤.٣٨ mg GAE/١٠٠g DW, ٦.٠٥ mg QE/١٠٠g DW and ٩٠.٥٧٪) compared with (٢.٢٦ mg GAE/١٠٠g DW, ١.٦٦ mg QE/١٠٠g DW and ٨٣.٦٣٪), respectively. These results were agreement with **Wang et al., (٢٠١٧); Wang et al., (٢٠٢٠)** who reported that flavonoids and phenolic acids are main bioactive compounds in JA and it has antioxidant effects by removing various free radicals. **Afoakwah et al., (٢٠١٥)** reported that sausages fortified with freeze-dried and oven-dried Jerusalem artichoke powder exhibited greater antioxidant activity compared to the control sample.

**Table (٢): Chemical composition of fresh and dried Jerusalem artichoke samples**

| Items | **Fresh** | **Dried** |
|---|---|---|
| **Moisture** | ٧٦.٣٣±٠.١ | ٦.٦٥±٠.٤٣ |
| **Total lipids** | ٠.٠٣±٠.١٦ | ٠.١٢±٠.١٠ |

| | | |
|---|---|---|
| **Crud protein** | ١.٩±٠.١ | ١٠.١٣±٠.١٠ |
| **Ash** | ١.٤٣±٠.١٢ | ٥.٥٥±٠.٢٠ |
| **Fiber** | ٠.٦١±٠.٠٣ | ٣.٩٤±٠.٢٠ |
| **Total carbohydrate** | ٢٠.٣١±٠.٦٢ | ٧٧.٥٥±٠.٢١ |
| **Energy** | ٨٩±٠.٨٧ | ٣٥٢±١.٨٥ |
| **Inulin (mg/١٠٠g)** | | |
| **Inulin** | ١٣.٩±٠.٠١ | ٥٨.٠١±٠.٠٦ |
| **Some minerals (mg/١٠٠g DW)** | | |
| **P** | ٠.١٨ | ٠.٦٢ |
| **Zn** | ٠.٧٦ | ٢.٦٢ |
| **Fe** | ١٠.١٤ | ١٤.٢٠ |
| **Ca** | ٣٢.٣٦ | ٨١.٦٠ |
| **Some phytochemical** | | |
| **Total phenol** (mg GAE/١٠٠g DW)** | ٢.٢٦±٠.١٢ | ٣٤.٣٨±٠.٤٩ |
| **Total flavonoids** (mg QE/١٠٠g DW)** | ١.٦٦±٠.٢٥ | ٦.٠٥±٠.١٦ |
| **Antioxidant activity DPPH (%)** | ٨٣.٦٣±٠.٠٥ | ٩٠.٥٧±٠.٠٧ |

*Value ± SD    ** Total phenols as Gallic acid (GAE) and total flavonoids as quercetin (QE

## Rheological properties of wheat flour substituted with different concentrations of Jerusalem artichoke powder

All measured values of rheological evaluation (Farinograph and extinsograph) of wheat flour samples substituted with Jerusalem artichoke powder were noted in table (٣). As shown, the values of water absorption ranged from ٦٣.٠٠% for control sample to ٤٦.٩٠% in sample ٦ which substituted with JAP (٥٠٪). Arrival time value ranged from ١.٠٠ to ٣.٠٠ (min.) as samples ١ (control sample) was the lowest value of arrival time but sample ٦ which substituted with JAP (٥٠٪) was the highest value. Dough development ranged between ٢.٥٠ and ٧.٢٠ (min.) sample ١ (control sample) was the lowest ٢.٥ min meanwhile sample ٦ which substituted with JAP (٥٠٪) had the best dough development time.

Stability value ranged from ١٢.٥٠ to ٢.٥٠, control sample had the highest value. On the other hand, sample ٦ which substituted with JAP (٥٠٪) had the lowest stability value. The same phenomenon was observed for degree of softening (B.U.) value, which reached from (٦٠ to ١٣ B.U) for sample ١(control sample) and samples ٦ which substituted with JAP (٥٠٪), respectively as compared to all samples. Resistance to extension (BU) value ranged between (٧٣٥ to ٧٠٠ B.U), sample ٣ which substituted with JAP (٢٠٪) had the highest value but sample ٢ which substituted with JAP (١٠٪) and sample ٦ which substituted with JAP (٥٠٪) was recorded the lowest value. Extensibility (mm) value decreased by addition Jerusalem artichoke powder as it ranged from ١٤٠ to ٤٠ mm) sample ١ had the highest value (١٤٠mm), but sample ٦ was the lowest value. Proportional number value increased by addition Jerusalem artichoke powder as it ranged between (١٧.٥٠ to ٥.٢١), sample ٦ which substituted with JAP (٥٠٪) had the highest value but sample ١ (control) was the lowest value. Energy value decreased by addition Jerusalem artichoke powder as it ranged between (١٢٠ to ٣٥ cm٢), sample ٦ which substituted with JAP (٥٠٪) had the lowest value (٣.٥ cm٢), but sample ١ (control) had the highest value. These results are nearly with **Nadir et al., (٢٠١١)** who reported that supplemented wheat flour with ١٠, ٢٠, ٣٠ and ٤٠٪ JAF led to a decreased in all of water absorption, stability and degree of softening and increased arrival time and dough development**.** An increase in dough development time suggests that a higher level of Jerusalem artichoke flour (JAF) or Jerusalem artichoke ingredients (JAI) in the dough slows down hydration and gluten formation. They also found that washing the dough and increasing the supplementation ratio of JAF led to decreased extensibility and resistance to extension. Additionally, the proportional numbers (R/E) for all dough's with JAF were higher than that of the control sample. Furthermore, dough energy diminished as the

JAF content increased, likely because JAF dilutes the gluten in the flour dough.

**Table (٣): Rheological properties of wheat flour substituted with different concentrations of Jerusalem artichoke powder**

| Samples | Rheological properties | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Farinograph test | | | | | Extensograph test | | | |
| | Water absorption (%) | Arrival time (min.) | Dough development (min.) | Stability | Degree of softening (B.U) | Resistance to extension (BU) | Extensibility (mm) | Proportional number | Energy (cm٢) |
| Control (wheat flour ٧٢٪ ext.) | ٦٣.٠٠ | ١.٠٠ | ٢.٥٠ | ١٢.٥٠ | ٦٠ | ٧٣٠ | ١٤٠ | ٥.٢١ | ١٢٠ |
| ١٠٪ JAP | ٥٨.٠٠ | ١.٢٥ | ٢.٩٠ | ١٠.١٠ | ٤٥ | ٧٠٠ | ٩٩ | ٧.٠٧ | ٨٠ |
| ٢٠٪ JAP | ٥١.٤٠ | ١.٧٠ | ٣.٥٠ | ٨.٥٠ | ٣٥ | ٧٣٥ | ٨٠ | ٩.١٩ | ٦٤ |
| ٣٠٪ JAP | ٥٠.٢٠ | ١.٩٥ | ٥.٠٠ | ٦.٠٠ | ٢٥ | ٧٣٠ | ٦٥ | ١١.٢٣ | ٥٧ |
| ٤٠٪ JAP | ٤٨.٦٠ | ٢.٥ | ٦.٠٠ | ٤.٢٠ | ٢٠ | ٧٢٥ | ٥٥ | ١٣.١٨ | ٤٢ |
| ٥٠٪ JAP | ٤٦.٩٠ | ٣.٠٠ | ٧.٢٠ | ٢.٥٠ | ١٣ | ٧٠٠ | ٤٠ | ١٧.٥٠ | ٣٥ |

## Chemical composition of cake substituted with different percentages of Jerusalem artichokes powder

The chemical composition of Jerusalem artichokes cake showed in table (٤). Results indicated that the ratio of moisture ranged between (١٩.٠٣±٠.٢٣) and (٢٦.٥٥±٠.٧٢). Moisture in cake sample supplemented with ٥٠٪ Jerusalem artichokes powder had the highest ratio, while the lowest one was in cake sample supplemented with ٤٠٪ Jerusalem artichokes powder. Total lipids ranged from (٢٠.٠٩±٠.٣٣) to (٢٣.٦٧±٠.٥٩) as the cake control sample had the highest level. On the other hand, cake sample supplemented with ٥٠٪ Jerusalem artichokes powder recorded the lowest value (٢٠.١٧٪). The cake sample supplemented with ٥٠٪ Jerusalem artichokes powder contains the highest percentage of protein (٢٠.٢٩±٠.٠١), but control sample was the lowest ratio of protein (١٩.١٣±٠.٠١). The percentage of ash was increased from (١.٥±٠.١٨) in the control sample to (٢.٧٩±٠.١٣) in cake sample supplemented with ٥٠٪ Jerusalem artichokes powder. Total carbohydrates content in cake sample supplemented with ٤٠٪ JAP had the highest level (٥٧.٤٩±٠.٦٩) meanwhile control cake sample recorded the last level (٥٥.٧٩±٠.٧٢). Also results noticed a difference in energy, whereas energy ranged from ٤٩٠±٠.٩٧ Kcal) in cake sample supplemented with ٥٠٪ Jerusalem artichokes powder to (٥١٣±٢.٦١ Kcal) for control sample. These results are in consistent with those reported by **Gedrovica et al., (٢٠١٠)** who said JAP increases the nutritional value of cakes substantially. Transforming Jerusalem artichoke into semi-finished products rich in functionally beneficial ingredients, and using them in a variety of food products, will contribute to the diversification of health-oriented offerings **(Bilenka et al., ٢٠١٩).** According, **(Ozgoren et al., ٢٠١٩)** who used Jerusalem artichoke powder (JAP) in crackers as a partial substitute of wheat (١٠, ٢٠, and ٣٠٪). The authors found that, additional of JAP caused a significant increase (p < ٠.٠٥) in ash, dietary fiber. **Ceylan et al., (٢٠٢١)** reported that the inclusion of Jerusalem artichoke flour (JAF) raised the ash content of cake samples from ١.٥٢g/١٠٠g to ٢.٠٧g/١٠٠g. Specifically, ١٠٠g of Jerusalem artichoke provides an energy value of ٥٧.٣kcal. Additionally, Jerusalem artichoke tubers contain a notable amount of natural nutrients, including ٢g of protein per ١٠٠g **(Zahorulko et al., ٢٠٢٣)**.

Data at the same table (٤) showed P, Zn Fe and Ca contents in Jerusalem artichokes cakes. The results indicated that P, Zn, Fe and Ca ranged between (٣٢٣.٢١ and ٤٥٧.٥١ mg/١٠٠g), (٢.٣٢ to ٢.٩٢ mg/١٠٠g), (٣.٨٤ and ١٠.٢٧ mg/١٠٠g) and (٧٩.٢٠ to ١١١.٤٠ mg/١٠٠g), respectively. Cake sample substituted with ٥٠٪ Jerusalem artichokes powder contains the highest percentage of minerals P, Zn, Fe and Ca under study. The lowest value of all minerals found in control cake sample. In general, increasing of Jerusalem artichoke powder led to a gradual increased in the percentage of minerals. The same conclusion of results was mentioned by **Ceylan et al., (٢٠٢١)** found that Ca, K and Mg contents of JAF cake samples were increased by increasing the amount of Jerusalem artichoke flour. **Marianna et al., (٢٠١٢)** found that supplementing cakes with Jerusalem artichoke powder (JAP) at a concentration of ٣٠٪ significantly raised the potassium (K) content compared to the control sample.

Data presented in table (٤) revealed the phytochemical composition [total phenol, total flavonoids and antioxidant activity (DPPH %)] in Jerusalem artichoke cake. Antioxidant activity (DPPH %) was ranged between (٧١.٥٣±٠.١٠%) and (٨٢.٢٩±٠.٢٦%). The control sample recorded the lowest level of antioxidant activity. Meanwhile, cake sample supplemented with ٥٠٪ Jerusalem artichokes had the highest level antioxidant activity. Cake samples were ranged of total phenol between

(٦٥.٨٣±١.٠٥ mg GAE/١٠٠g DW) and (١٦٠.٣٥±١.٥١ mg GAE/١٠٠g DW). The control sample recorded the lowest level but cake sample supplemented with ٥٠٪ Jerusalem artichokes had the highest level. Also total flavonoids content in the samples were ranged from (١.٦٩±٠.٠٣ mg QE/١٠٠g DW) to (٤.٤٤±٠.٠٨ mg QE/١٠٠g DW). The control sample recorded the lowest level while; cake sample supplemented with ٥٠٪ Jerusalem artichokes had the highest level. These results are consistent with **Ceylan et al., (٢٠٢١)** who reported that JAF increased total antioxidant activity and phenolic content contents of cake samples. **Catană et al. (٢٠١٨)** noted that Jerusalem artichoke tubers possess antioxidant potential. The complex biochemical composition of the functional ingredient derived from these tubers can be utilized to fortify food products. Additionally, **Lee, (٢٠١٦)** stated that the antioxidant activity of samples containing Jerusalem artichoke flour (JF) was significantly higher than that of other samples.

**Table (٤): Chemical composition of cake substituted with different ratio of Jerusalem artichokes powder (on dry weight basis)**

| Items | Jerusalem artichokes cake samples | | | | | |
|---|---|---|---|---|---|---|
| | Control (١) | ٢ | ٣ | ٤ | ٥ | ٦ |
| **Moisture** | ٢١.٧٧±٠.٤٦ab | ١٩.٥٣±١.٦٧a | ٢٣.١±٠.١٩b | ٢٠.٥±١.٠٧ab | ١٩.٠٣±٠.٢٣a | ٢٦.٥٥±٠.٧٢c |
| **Total lipids** | ٢٣.٦٧±٠.٥٩a | ٢٢.٦٤±٠.١٥ab | ٢٢.٠٣±٠.٧٨b | ٢١.٤٧±٠.٣٣b | ٢٠.٦٥±٠.٤٢ab | ٢٠.١٧±٠.٠٩ab |
| **Crud protein** | ١٩.١٣±٠.٠١f | ١٩.٣٦±٠.٠١e | ١٩.٥٩±٠.٠١d | ١٩.٨٣±٠.٠١c | ١٩.٤٤±٠.٠١b | ٢٠.٢٩±٠.٠١a |
| **Ash** | ١.٥±٠.١٨c | ١.٨٧±٠.٠٩bc | ١.٩٨±٠.٤٩abc | ٢.١٢±٠.١٩abc | ٢.٥١±٠.٣١ab | ٢.٧٩±٠.١٣a |
| **Total carbohydrate** | ٥٥.٧٩±٠.٧٢ab | ٥٦.١٣±٠.١١ab | ٥٦.٤±٠.٤٤ab | ٥٦.٥٧±٠.٣٤a | ٥٧.٤٩±٦٩ab | ٥٦.٧٥±٠.٠٥b |
| **Energy** | ٥١٣±٢.٦١ab | ٥٠٦±٠.٩٩ab | ٥٠٢±٥.٤١b | ٤٩٩±١.٩٤b | ٤٩٣±١.٣١b | ٥٩٠±٠.٩٧b |
| **Some minerals (mg/١٠٠g DW)** | | | | | | |
| **P** | ٣٢٣.٢١ | ٣٥٠.١ | ٣٧٦.٩٨ | ٤٠٣.٨٥ | ٤٣٠.٧٣ | ٤٥٧.٦١ |
| **Zn** | ٢.٣٢ | ٢.٦٣ | ٢.٧٠٤ | ٢.٧٨ | ٢.٨٥ | ٢.٩٢ |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Fe** | ٣.٨٤ | ٥.١٢٦ | ٦.٤١٢ | ٧.٧ | ٨.٩٨٤ | ١٠.٢٧ |
| **Ca** | ٧٩.٢ | ٨٥.٦٤ | ٩٢.٠٨ | ٩٨.٥٢ | ١٠٤.٩٦ | ١١١.٤ |
| **Some phytochemical** | | | | | | |
| **Total phenol** (mg GAE/١٠٠g DW)* | ٦٥.٨٣±١.٠٥[b] | ٩٠.٦±٠.٦٩[b] | ٩٨.٦٤±١.٣٢[b] | ١٣٢.٧٩±٠.٦٧[a] | ١٣٣.٥±١.٥٧[a] | ١٦٠.٣٥±١.٥١[a] |
| **Total flavonoids** (mg QE/١٠٠g DW)* | ١.٦٩±٠.٠٣[d] | ١.٨٤±٠.٠٦[d] | ٢.١٤±٠.١٥[c] | ٣.٧٤±٠.١٣[b] | ٤.٣٧±٠.٠٥[a] | ٤.٤٤±٠.٠٨[a] |
| **Antioxidant activity DPPH (%)** | ٧١.٥٣±٠.١[e] | ٧٤.٥٨±٠.١٤[e] | ٧٦.٧±٠.١٨[d] | ٧٨.٧٨±٠.١٣[c] | ٨٠.١١±٠.٢٣[b] | ٨٢.٢٩±٠.٢٦[a] |

* Total phenols as Gallic acid (GAE) and total flavonoids as quercetin (QE

** Value ± SD with the same latter at the same raw are not significantly different (P≤٠.٠٥).

١: Control cake sample without Jerusalem artichokes powder

٢: Cake with Jerusalem artichokes powder by ١٠٪ +٩٠٪ wheat flour

٣: Cake with Jerusalem artichokes powder by ٢٠٪ +٨٠٪ wheat flour

٤: Cake with Jerusalem artichokes powder by ٣٠٪ +٧٠٪ wheat flour

٥: Cake with Jerusalem artichokes powder by ٤٠٪ +٦٠٪ wheat flour

٦: Cake with Jerusalem artichokes powder by ٥٠٪ +٥٠٪ wheat flour

**Effect of addition different percentages of Jerusalem artichokes powder in cake on texture analysis**

The texture analysis for cake substituted with JAP showed in table (٥). Results indicated that the values of hardness cycle (N) and springiness (mm) levels increased during the storage period (٢ weeks). Meanwhile gumminess (N) levels decreased during the storage period (٢ weeks).

Hardness cycle ranged from ٥.٧٧ N to ٨.٤٥ N at zero time, the highest level of hardness cycle was found in sample ٦ which substituted with JAP (٥٠٪). On the other hand the cake control sample was the lowest. During the storage period, hardness cycle of all treatments were increased reached from ٢٢.٧٥ N to ٣٢.٧١ N after ٢ weeks. Also sample ٦ which substituted with JAP (٥٠٪) recorded the highest level but control cake sample also was the lowest levels.

Springiness ranged from ٠.٥٥ mm to ٠.٧٨ mm at zero time, the highest level of springiness was found in sample ٦ which substituted with JAP (٥٠٪). On the other hand, the sample ١ (control sample) was the lowest value. During the storage period, springiness of all treatments was increased reached from ٣.٢١ mm to ٨.١١ mm. Also sample ٦ which substituted with JAP (٥٠٪) recorded the highest level but sample ١ (control sample) was the lowest.

Gumminess ranged from ١٠.٧٨ mm to ١٩.٥٣ N at zero time, the highest level of gumminess was found in sample ١ (control sample). On the other hand the sample ٦ which substituted with JAP (٥٠٪) was the lowest value. During the storage period, gumminess of all treatments were decreased reached from ١٠.٢٥ N to ٥.٨٢ N. Sample ١ (control sample) recorded the highest level but sample ٦ which substituted with JAP (٥٠٪) was the lowest. These results are similar to **Wongsadee et al., (٢٠٢٣)** who reported that hardness and chewiness increased in sponge cake samples with Jerusalem artichoke flour whereas the cohesiveness and springiness decreased compared with the control sample. **Ceylan et al., (٢٠٢١)** reported that using resistant starch (RS) at high ratios, or a combination of Jerusalem artichoke flour (JAF) and RS at levels above ١٠٪ in cake formulations, resulted in decreased volume and symmetry index, as well as increased hardness of the cake samples. Conversely, the addition of guar gum enhanced both the volume index and hardness of the cakes. Additionally, **Celik et al., (٢٠١٣)** indicated that Jerusalem artichoke flour possesses favorable physicochemical characteristics that can enhance the texture properties of cakes and improve the nutritional value of the dough.

**Table (٥): Effect of different percentages of Jerusalem artichokes powder on cake texture during storage period (٢ weeks)**

| Jerusalem artichokes cake treatments | | Constituents | | |
|---|---|---|---|---|
| | | Hardness Cycle (N) | Springiness (mm) | Gumminess (N) |
| Zero time | ١ | ٥.٧٧ | ٠.٥٥ | ١٩.٥٣ |
| | ٢ | ٥.٨٥ | ٠.٥٨ | ١٨.٩٨ |
| | ٣ | ٦.٠١ | ٠.٦١ | ١٨.٨٧ |
| | ٤ | ٦.٣٥ | ٠.٦٢ | ١٦.٧٤ |
| | ٥ | ٨.١٣ | ٠.٧٠ | ١٠.٨٢ |
| | ٦ | ٨.٤٥ | ٠.٧٨ | ١٠.٧٨ |
| After a week | ١ | ١٢.١١ | ٤.٣٧ | ١٣.٢٢ |
| | ٢ | ١٣.٥٢ | ٥.٤٢ | ١٢.٠٠ |
| | ٣ | ١٤.٨١ | ٥.٩٥ | ١١.٥٣ |
| | ٤ | ١٦.٧٣ | ٦.٤٣ | ١٠.١٦ |
| | ٥ | ١٨.٢٥ | ٧.١٣ | ٨.٤٨ |
| | ٦ | ٢٠.٠٨ | ٨.٠٧ | ٧.٠٩ |
| After ٢ weeks | ١ | ٢٢.٧٥ | ٣.٢١ | ١٠.٢٥ |
| | ٢ | ٢٣.٦٥ | ٤.٣٩ | ٩.٦٥ |
| | ٣ | ٢٥.٤٧ | ٥.٠٣ | ٨.٤٧ |
| | ٤ | ٢٧.١١ | ٥.٩٨ | ٧.٨٦ |
| | ٥ | ٢٩.٩٣ | ٦.٨٦ | ٦.١٣ |
| | ٦ | ٣٢.٧١ | ٨.١١ | ٥.٨٢ |

١: Control cake sample without Jerusalem artichokes powder
٢: Cake with Jerusalem artichokes powder by ١٠٪ +٩٠٪ wheat flour
٣: Cake with Jerusalem artichokes powder by ٢٠٪ +٨٠٪ wheat flour
٤: Cake with Jerusalem artichokes powder by ٣٠٪ +٧٠٪ wheat flour
٥: Cake with Jerusalem artichokes powder by ٤٠٪ +٦٠٪ wheat flour
٦: Cake with Jerusalem artichokes powder by ٥٠٪ +٥٠٪ wheat flour

**Sensory properties of cake substituted with different percentages of Jerusalem artichokes powder**

Sensory properties of crust color, crumb color, odor , texture, taste, grains and overall acceptability of Jerusalem artichokes cake shown in table (٦)

The crust color of cake samples was ranged from (٦.٩١±٠.٣٧ to ٩.٩±٠.٩١). The lowest value was found in cake sample substituted with ٣٠٪ Jerusalem artichokes powder and the highest value was found in cake sample substituted with ١٠٪ Jerusalem artichokes powder. Statistical analysis of the data showed that there was a significant difference of the crust color level between all samples.

The crumb color level of cake samples were ranged from (١٤.٩١±١.٠٧) to (١٨.١٠±٠.٢٣). The lowest value was found in sample which contained ٣٠٪ JAP and the highest level was found in cake sample substituted with ٥٠٪ Jerusalem artichokes powder. Statistical analysis of the data showed that there wasn't a significant difference of the crumb color values between all samples.

Results showed that odor values of cake samples were ranged from (١٢.٢٧±٠.٧٥ to ١٤.١±٠.٣٥). Cake sample substituted with ٥٠٪ Jerusalem artichokes powder recorded the best result of odor value but cake sample substituted with ٣٠٪ Jerusalem artichokes powder had the lowest level. Statistical analysis of the data showed that there wasn't a significant difference of the odor level between all samples.

Results indicated that texture values ranged from (١٢.٢±٠.٦٥ to ١٨.٤±٠.١٣). The highest texture level was found in control sample and the lowest texture level was found cake sample substituted with ٤٠٪ Jerusalem artichokes powder. Statistical analysis of the data showed that there was a significant difference of the texture level between all samples.

Results showed that taste values of cake samples were ranged from (١٦.٨±٠.٧١ to ١٩.٥±٠.١٧). Control cake sample recorded the best result of taste value but cake sample substituted with ٤٠٪ Jerusalem artichokes powder had the lowest level. Statistical analysis of the data showed that there was a significant difference of taste between all samples.

Results indicated that grains level ranged from (١٦±١.٠٢) to (١٩.٤±٠.٢٧). The highest grains level was found in control cake and the lowest grains level was found cake sample substituted with ٤٠٪ Jerusalem artichokes powder. . Statistical analysis of the data showed that there was a significant difference of taste between all samples.

Results showed that overall acceptability levels of Jerusalem artichoke cake were ranged from (٧٩.٥٥±٣.٠٩) to (٩٣.٧±١.٦). Control sample recorded the best result of overall acceptability level while cake sample substituted with ٣٠٪ Jerusalem artichokes powder had the lowest level. Statistical analysis of the data showed that there was a significant difference of the overall acceptability level between all samples. The obtained results in the current work were agreed with the previous work of **Wang et al., (٢٠٢١)** and **Yovchev and Le-Bial, (٢٠٢١),** which said that fortifying products with artichoke powder improved their organoleptic properties. Diaz et al., (٢٠١٩) reported that substituting wheat flour with Jerusalem artichoke powder (JAP) in biscuit production at levels of ٢٥٪, ٥٠٪, ٧٥٪, and ١٠٠٪ resulted in ΔE values of ١١.١, ١٩.٩, ٢٢.٨, and ٢٣.٤, respectively. Rashid et al., (٢٠١٨) found that Jerusalem artichoke inulin showed better results regarding water loss, cake height, and volume when compared to equivalent treatments with chicory inulin.

**Table (٦): Sensory properties of cake substituted with different percentages of Jerusalem artichokes powder**

| Properties (%) | Jerusalem artichokes cake treatments | | | | | |
|---|---|---|---|---|---|---|
| | ١ | ٢ | ٣ | ٤ | ٥ | ٦ |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Crust color** | ٩.٨٠±٠.١٣[a] | ٩.٩٠±٠.٩١[b] | ٨.٣٠±٠.٢٦[b] | ٦.٩١±٠.٣٧[c] | ٧.٣٠±٠.٣[bc] | ٧.٩٠±٠.٢٨[bc] |
| **Crumb color** | ١٦.٨٠±١.٤٩[a] | ١٦.٢٠±١.٣٩[a] | ١٥.٨٠±١.٣٥[a] | ١٤.٩١±١.٠٧[a] | ١٥.١٠±١.١٥[a] | ١٨.١٠±٠.٢٣[a] |
| **Odor** | ١٣.٤٠±٠.٥٨[a] | ١٣.٥٠±٠.٥٨[a] | ١٢.٩٠±٠.٥٧[a] | ١٢.٢٧±٠.٧٥[a] | ١٣.٠٠±٠.٤٧[a] | ١٤.١٠±٠.٣٥[a] |
| **Texture** | ١٤.٨٠±٠.١٣[a] | ١٤.٢٠±٠.٩[a] | ١٢.٩٠±٠.٨٦[bc] | ١٢.٧٣±٠.٥٩[bc] | ١٢.٢٠±٠.٦٥[c] | ١٣.٤٠±٠.٢٢[ab] |
| **Taste** | ١٩.٥٠±٠.١٧[a] | ١٨.٥٠±٠.٥٨[ab] | ١٧.٣٠±٠.٧٢[b] | ١٧.١٨±٠.٦٢[b] | ١٦.٨٠±٠.٧١[b] | ١٨.١٠±٠.١٨[ab] |
| **Grains** | ١٩.٤٠±٠.٢٧[a] | ١٨.٨٠±٠.٢٩[ab] | ١٧.١٠±٠.٦٦[bc] | ١٦.٥٥±٠.٧٤[cd] | ١٦.٠٠±١.٠٢[d] | ١٧.٧٠±٠.٢٦[abc] |
| **Overall acceptability** | ٩٣.٧٠±١.٦[a] | ٩١.١٠±٢.٢٦[ab] | ٨٤.٣٠±٢.٤٧[bc] | ٧٩.٥٥±٣.٠٩[c] | ٨٧.٤٠±٢.٩٤[c] | ٨٩.٣٠±٠.٩٢[ab] |

Value ± SD with the same latter at the same raw are not significantly different (P≤٠.٠٥).

١: Control cake sample without Jerusalem artichokes powder
٢: Cake with Jerusalem artichokes powder by ١٠٪ +٩٠٪ wheat flour
٣: Cake with Jerusalem artichokes powder by ٢٠٪ +٨٠٪ wheat flour
٤: Cake with Jerusalem artichokes powder by ٣٠٪ +٧٠٪ wheat flour
٥: Cake with Jerusalem artichokes powder by ٤٠٪ +٦٠٪ wheat flour
٦: Cake with Jerusalem artichokes powder by ٥٠٪ +٥٠٪ wheat flour

## Reference

**A.A.C.C (٢٠٠٠).** Approved methods of the AACC (١٠th ed.). St Paul, MN: American Association of Cereal Chemists (Methods ٠٨-٠١, ٣٠-٢٥. ٤٤-١٥A, ٤٦-١٠, ٥٤-١٠, ٥٤-٢١.

**A.O.A.C (٢٠٠٠).** Association of Official Analytical Chemists. In Official Methods of Analyses, ١٧th ed. Gaithersburg. M.D.

**A.O.A.C (٢٠١٠).** Official Methods of Analysis of the Association of the Analytical Chemists. ١٨ed published by the Association of Official Analytical Chemists. Po Box ٥٤٠. Benjamin Franklin Station Washington DC. ٢٠٠٤٤.

**AboTaleb, HMA (٢٠١٨).** Evaluation of some products from tartufi (Jerusalem artichoke) tubers. Middle East Journal Applied Sciences, ٨ (٣);١٠١١-١٠٢٣

**Afoakwah, NA.; Dong, Y.; Zhao, Y.; Xiong, Z.; Owusu, J.; Wang, Y and Zhang, J (٢٠١٥).** Utilization of Jerusalem Artichoke (Helianthus tuberosus L.) Tuber as a Prebiotic and a Synbiotic. LWT-Food. Sci. Technol ٦٤, ٧٤–٨١.

**Ammar, I.; Gharsallah, H.; Brahim, AB.; Attia, H.; Ayadi, MA.; Hadrich, B and Felfoul, I (٢٠٢٠).** Optimization of gluten-free sponge cake fortified with whey protein concentrate using mixture design methodology. Food Chemistry, ٣٤٣:١٢٨٤٥٧.

**Arnous, A.; Makris, DP and Kefalas, P (٢٠٠١).** Effect of principal polyphenol components in relation to antioxidant characteristics of aged red wines. J. Agric. Food Chem., ٤٩ (١٢), ٥٧٣٦–٥٧٤٢.

**Baldini, M.; Danuso, F.; Turi, M and Vannozzi, GP (٢٠٠٤).** Evaluation of new clones of Jerusalem artichoke (*Helianthus tuberosus L*.) for inulin and sugar yield from stalks and tubers. Industrial Crops and Products, ١٩(١), ٢٥-٤٠.

**Barkhatova, TV.; Nazarenko, MN.; Kozhukhova, MA and Khripko, IA (٢٠١٥).** Obtaining and identification of inulin from Jerusalem artichoke (*helianthus tuberosus*) tubers. Foods and raw materials ٣(٢):١٣-٢٢ , DOI: ١٠.١٢٧٣٧/١٣١١٥.

**Bicāne, A (٢٠٠٧)**. Jaunā konditora rokasgrāmata (Guide for the pastry-cook), SIA Biznesa augstskola Turība, Rīga, ٤٧٤. lpp. (in Latvian).

**Bilenka, I.; Lazarenko, N.; Zolovska, O and Dzyuba, N (٢٠١٩).** complex processing of *jerusalem artichoke* into functional products. Food Science and Technology, ١٣(٤),٨٧-٩٥. https://doi.org/١٠.١٥٦٧٣/fst.v١٣i٤.١٥٥٩ .

**Bourne, MC (٢٠٠٣).** Food Texture and Viscosity: Concept and Measurement' Elsevier Press, New York, London.

**Brand-Williams, W.; Cuvelier, ME and Berset, C (١٩٩٥).** Use of a free radical method to evaluate antioxidant activity. LWT- Food Science and Technology, ٢٨ (١): ٢٥–٣٠.

**Butin, KB.; Batykova, BM and Iztelets, KKZ (٢٠٠٦).** Lipids of (*Helianthus tuberosus*) .UDC., ٤(١١): ٥٤٧.٩١٦.٦٦٥:٣٣.

**Catană, L.; Catană, M.; Iorga, E.; Lazăr, A-G.; Lazăr, M-A.; Teodorescu, R.; Asănică, A.; Belc, N and Iancu, A (٢٠١٨).** Valorification of Jerusalem Artichoke Tubers (*Helianthus Tuberosus*) for Achieving of Functional Ingredient with High Nutritional Value. Agriculture for Life for Agriculture, Conference Proceedings ١(١):٢٧٦-٢٨٣.

**Celik, I.; Isik, F.; Gursoy, O and Yilmaz,Y (٢٠١٣).** Use of Jerusalem artichoke (*Helianthus tuberosus*) tubers as a natural source of inulin in cakes. J. Food Process. Preserv., ٣٧:٤٨٣-٤٨٨

**Ceylan, H.; Bilgiçli, N and Cankurtaran, T (٢٠٢١).** Improvement of functional cake formulation using Jerusalem artichoke flour as inulin source and resistant starch (RS٤). SINAI Journal of Applied Sciences ١٢ (١) ٢٠٢٣ ٠٢٧-٠٤٠

**Chang, C.; Yang, M.; Wen, H and Chern, J (٢٠٠٢).** Estimation of total flavonoid content in propolis by two complementary colorimetric methods. J. Food Drug Anal. ١٠, ١٧٨–١٨٢.

**Chang, WC and Jia, HAWW (٢٠١٤).** Benefcial effects of soluble dietary Jerusalem artichoke (*H. tuberosus*) in the prevention of the onset of type ٢ diabetes and non-alcoholic fatty liver disease in highfructose diet-fed rats J. British J of Nutr., ١١٢(٥), ٧٠٩-٧١٧.

**Diaz, A.; Bomben, R.; Dini, C.; Vina, SZ.; Garcia, MA.; Ponzi, M and Comelli, N (٢٠١٩).** Jerusalem artichoke tuber flour as a wheat flour substitute for biscuit elaboration. LWT- Food Sci. Technol. ١٠٨, ٣٦١–٣٦٩.

**Downer, B.; Estus, S.; Katsumata, Y and Fardo, DW (٢٠١٤).** Longitudinal Trajectories of Cholesterol from Midlife through Late Life according to Apolipoprotein E Allele Status. Journal of Environ Res Public Health, ١١(١٠): ١٠٦٦٣–١٠٦٩٣.

**El-Kholy, WM and Mahrous, H (٢٠١٥).** Biological Studies on Bio-Yoghurt Fortified with Prebiotic Obtained from Jerusalem artichoke. Food and Nutrition Sciences, ٦(١٦):١٥٥٢-١٥٦٤.

**El-Sohaimy, SA (٢٠١٤).** Chemical composition, antioxidant and antimicrobial potential of artichoke. Open Nutraceuticals J., ٧:١٥-٢٠, DOI: ١٠.٢١٧٤/١٨٧٦٣٩٦٠٠١٤٠٧٠١٠٠١٥.

**FAO/WHO/UNU (١٩٨٥).** Protein Quality Evaluation Report of a Joint FAO/WHO expert cultivation FAO/WHO Rome, Italy.

**Gedrovica, I.; Karkliņa, D. and Straumite, E. (٢٠١٠):** Sensory and qualitative indices (hardness and colour) evaluation of cakes with jerusalem artichoke (*Helianthus tuberosus L.*) powder. Journal of food sciences, ١:١٣٨-١٤٤.

**Guiné, RPF and Florença, SG (٢٠٢٤).** Development and Characterisation of Functional Bakery Products. Journal of Physchem., ٤(٣), ٢٣٤-٢٥٧.

**Harmankaya, M.; Al Juhaimi, F and Zcan, MM (٢٠١٢).** Mineral contents of Jerusalem artichoke (*Helianthus tuberosus L.*) growing wild in Turkey. Anal. Lett., ٤٥:٢٢٦٩-٢٢٧٥

**Horochowska, M.; Kołeczek, E.; Zdrojewicz, Z.; Jagiełło, J.; Pawlus, K.; Odżywcze, T-W and bulwiastego, LS (٢٠١٧).** (*Helianthus tuberosus L.*). Review article Pediatr Endocrinol Diabetes Metab., ٢٣(١): ٣٠–٣٦.

**Kaur, N and Gupta, AK (٢٠٠٢).** Applications of Inulin and Oligofructose in Health and Nutrition. Journal of Biosciences, ٢٧ (٧): ٧٠٣-٧١.

**Kays, SJ and Nottingham, SF (٢٠٠٧).** Biology and chemistry of Jerusalem artichoke: (*Helianthus tuberosus L.*) J Agr Food Chem., ١٠(٤):٣٥٢–٣٥٣.

**Kita, A.; Nowak, J and Michalska-Ciechanowska, A (٢٠٢٠).** The Effect of the Addition of Fruit Powders on the Quality of Snacks with Jerusalem Artichoke during Storage. Journal of Appl. Sci., ١٠(١٦), ٥٦٠٣.

**Kronberga, M.; Gedrovica, I and Karklina, D (٢٠١٣).**The Influence of Jerusalem Artichoke as Nutrition Value Increaser on Microbiological Parameters of Confectionery Products, ٢nd International Conference on Nutrition and Food Sciences IPCBEE, ٥٣: ١٦–٢٣.

**Lee, YR (٢٠١٦).** Analysis of Nutritional Components and Antioxidant Activity of Roasting Wooung (*Burdock, Arctium lappa L.*) and Jerusalem Artichoke (*Helianthus tuberosus L.)*. The Korean Journal of Food And Nutrition ٢٩(٦):٨٧٠-٨٧٧.

**Linden, G (١٩٩٥).** Analytical Techniques for Foods and Agricultural Products. In: Multon J.L., Linden G., Bourgeois C.M., Leveau J. – Y

Analysis and Control Methods for Foods and Agricultural Products, VCH Publishers, USA, pp. ٤٠٥-٤٧٧.

**Lv, PS.; Wang, R.; Xiao, Y.; Fencan Li, F.; Mu, Y.; Lu, Y.; Gao, W.; Yang , B.; Kou, Y.; Zeng, J and Zhao, C (٢٠١٩).** Growth, yield formation, and inulin performance of a non-food energy crop, Jerusalem artichoke (*Helianthus tuberosus L.)*, in a semi-arid area of China. Industrial Crops and Products, ١٣٤: ٧١-٧٩.

**Marianna, B.; Iliana, M-T.; Tzvetana, G and Stanislava, A (٢٠١٢).** Preparation of sponge cakes with flour of Topinambur tubers. J. Biol. Biomol. Food Biotechnl., Eng., ٦(٧), ٥٢٤–٥٢٧.

**Munim, A.; Rod, MRM.; Tavakoli, H and Hosseinian, F (٢٠١٧).** An Analysis of the Composition, Health Benefits, and Future Market Potential of the Jerusalem Artichoke in Canada. Journal of Food Research ٦(٥):٦٩.

**Nabeshima, EH.; Moro, TMA.; Campelo, PH.; Sant'Ana, AS.; Teresa, MPS and Clerici, MTPS (٢٠٢٠).** Chapter Seven – Tubers and roots as a source of prebiotic fibers. Probiotics and Prebiotics in Foods, Challenges, Innovations, and Advances, ٢٠١-٢١٧.

**Nadir, AS.; Helmy, IMF and Kamil, MM (٢٠١١).** Effect of Using Jerusalem Artichoke and Inulin Flours on Producing Low Carbohydrate High Protein Pasta. Australian Journal of Basic and Applied Sciences, ٥(١٢): ٢٨٥٥-٢٨٦٤.

**Najjaa, H.; Ben Arfa, A.; Elfalleh, W.; Zouari, N and Neffati, M (٢٠٢٠).** Jujube (*Zizyphus lotus L.*): Benefits and its effects on functional and sensory properties of sponge cake. Journal of PloS One,١٥(٢): ٠٢٢٧٩٩٦.

**Ozgoren, E.; Isik, F and Yapar, A (٢٠١٩**). Effect of Jerusalem artichoke (*Helianthus tuberosus L.*) supplementation on chemical and nutritional properties of crackers. Journal of Food Measurement and Characterization, ١٣ (٤):٢٨١٢–٢٨٢١.

**Park, BS (٢٠١١).** Effect of oral administration of Jerusalem artichoke inulin on reducing blood lipid and glucose in STZ-induced diabetic rats. Journal of Anim Vet Adv., ١٠: ٢٥٠١–٧.

**Raeker, MO and Johnson, LA (١٩٩٥).** A micro method for cake baking (high raio, white layer). Cereal Chem., ٧٢(١):١٦٧-١٧٢.

**Rashid, S.; Rakha, A.; Butt, MS and Asgher, M (٢٠١٨).** Physicochemical and techno-functional characterization of inulin extracted from chicory roots and Jerusalem artichoke tubers and exploring their ability to replace the fat in cakes. Progress in Nutrition, ٢٠(٢): ١٩١-٢٠٢.

**Rubel, IA.; Iraporda, C.; Manrique, GD and Genovese, DB (٢٠٢٢).** Jerusalem Artichoke (*Helianthus tuberosus L.*) inulin as a suitable bioactive ingredient to incorporate into spreadable ricotta cheese for the delivery of probiotic. Bioactive Carbohydrates and Dietary Fibre, ٢٨:١-٨.

**Rushchitc, AA.; Shcherbakova, EI and El-Sohaimy, SA (٢٠٢٢).**

Physicochemical and rheological characterization of dumpling's dough fortified with Jerusalem artichoke (*Helianthus tuberosus*) powder. Annals of Agricultural Sciences, ٦٧(٢):١٦٦-١٧٢.

**Saiki, P.; Yoshihara, M.; Kawano, Y.; Miyazaki, H and Miyazaki, K (٢٠٢٢).** Anti-Inflammatory Effects of Heliangin from Jerusalem Artichoke (Helianthus tuberosus) Leaves Might Prevent Atherosclerosis. Journal of Biomolecules., ١٢(١):٩١.

**Sawicka , B.; Skiba, D.; Pszczółkowski, P; Aslan, I.; Sharifi-Rad, J and Krochmal-Marczak, B (٢٠٢٠).** Jerusalem artichoke (*Helianthus tuberosus L.*) as a medicinal plant and its natural products. Cell Mol Biol (Noisy-le-grand), ٢٥,٦٦(٤):١٦٠-١٧٧.

**Snedecor, GW and Cochran, WG (١٩٨٩).** Statistical Methods. The lowe State University Press. Ames, Lowe.

**Sobel, A and Matławska, I (٢٠٠٥).** Plants-based and herbal preparations in healthy slimming diets. Herba Polonica, ٥١ (١): ١٩٠–١٩٢.

**Soliman, SA (١٩٩٦).** Studies on wheat flour milling products and their effect on the quality of some bakery products. M. Sc. thesis. Fac. of Agric., Cairo University, Egypt.

**USDA (٢٠٢٠).** United States Department of Agriculture Agricultural Research Service Food Composition Databases.

**Voss, GB.; Campos, DA and Pintado, MM (٢٠٢١).** Chapter ١١ – Cereal Bars Added With Probiotics and Prebiotics. Probiotics and Prebiotics in Foods, Challenges, Innovations, and Advances, ٢٠١-٢١٧.

**Wang, H.; Zhang, J.; Wang, R.; Liu, X.; Zhang, Y.; Sun, J.; Su, L and Zhang, H (٢٠٢١).** Improving quality attributes of sweet dumplings by germination: effect of glutinous rice flour microstructure and physicochemical properties. Food Biosci., ٤٤: ١٠١٤٤٥.

**Wang, Y.; Zhao, Y.; Xue, F.; Nan, X.; Wang, H.; Hua, D.; Liu, J.; Yang, L.; Jiang, L and Xiong, B (٢٠٢٠).** Nutritional value, bioactivity, and application potential of Jerusalem artichoke (Helianthus tuberosus L.) as a neotype feed resource. Anim Nutr., ٦(٤): ٤٢٩–٤٣٧.

**Wang, YM.; Zhao, JQ.; Yang, JL.; Idong, PT and Shi, YP (٢٠١٧).** Antioxidant and α -glucosidase inhibitory ingredients identified from Jerusalem artichoke flowers. Nat Prod Res., ٣٣(٤):١–٥.

**Wongsadee, T.; Salakkham, P and Srithong, N (٢٠٢٣).** Effect of wheat flour partial substitution with jerusalem artichoke flour on quality of sponge cake *kochchasarn*. Journal of science, ٤٥(١); ٢١-٢٩.

**Yovchev, AG and Le-Bial, A (٢٠٢١).** Effect of Jerusalem artichoke flour on wheat dough physical and mechanical properties. Appl. Food Res., ١(٢):١٠٠٠٢٦.

**Zahorulko, A.; Zagorulko, A.; Postadzhiev, A and Nataliia Tytarenko, N (٢٠٢٣).** Improvement of the manufacturing method of semi-finished fruit and vegetables of a high degree of readiness. Eureka: Life Sciences, ٢.