EDIOTERIAL | Egyptian Journal of Agricultural Research | Food Technology

Effect of varieties and harvesting time on yield, chemical composition, and quality of a product similar to chips produced from Jerusalem artichoke

Hassan I. Abd El-hakim Ahmed, [1*] *and Fatma S.S. Alian*[2].

Address:

[1] *Department of Horticultural Crops Technology Research, Food Technology Research Institute, Agriculture Research Center, Egypt.*

[2] *Potato and Vegetatively Propagated Vegetables Department, Horticulture Research Institute, Agriculture Research Center, Egypt.*

*Corresponding author, ***Hassan Ismail Abd El-Hakim Ahmed***: ahi_20026@yahoo.com

Received: 11-11-2022 ; **Accepted**: 60-04-2023 ; **Published:** 09-04-2023 DOI, 10.21608/EJAR.2023.174166.1298

ABSTRACT

Jerusalem artichoke is grown in different regions and is widely consumed as food. It has a distinct flavor, and, it is an excellent source of inulin, plant, phytochemicals, and some functional nutritional ingredients including dietary fiber and minerals. This study was conducted to assess the effect of varieties and harvest time at 240 and 270 days after planting (December 15 and January 15) respectively, on the total yield of tubers ton /fed as well as kg/plant, average tubers weight, and chemical composition. Also, to test the possibility of producing chips from two varieties of Jerusalem artichoke at two harvest times, frying at different temperatures degrees (170°C, 180°C) and using some technological treatments. The chemical composition of raw materials, processed chips, organoleptic changes, color parameters, and hardness values of the final product were studied. The obtained results showed that the Fuseau variety and the second harvest time were better in terms of the total yield of tubers, the average tuber weight, chemical components, and the production of chips than the Balady variety. It can also be concluded that treatment No. 4 (in which the slices were soaked in a solution containing 2% acetic acid and 1% citric acid), especially, at a temperature of 180 °C, was the best in preserving many important components, as well as imparting distinctive color properties. In addition, this treatment led to improve sensory quality characteristics based on the sensory evaluation of the majority of panelists. Hence, Jerusalem artichoke chips are recommended as snack foods.

Keywords: Jerusalem artichoke, chips, Physico-chemical properties.

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus* L.) is a flowering plant of the family Asteraceae. It is a plant with a long history of cultivation that has been making a revival as an edible vegetable in recent years. Jerusalem artichoke is a minor crop, Food and Agriculture Organization (FAO) and EUROSTAT statistics for its cultivated area are not available Michalska-Ciechanowska *et al*. (2019). This crop is a tuberous crop that was recently introduced to Egypt for its high nutritional and medicinal value. The tubers are known to be a health-promoting food source that contains inulin instead of starch as a carbohydrate reserve (Khuenpet *et al*., 2017). According to beneficial health and nutritive effects, it contains inulin as a natural dietary fiber that could be a valuable component of food products (Murphy, 2001; Taleb *et al.,* 2018).

Moreover, it has no fat and has relatively low-calorie. Inulin is a polysaccharide composed of fructose, is and legally classified as a food ingredient and a low-calorie sweetener (Glibowski and Wasko, 2008). It has been promoted as a healthy choice for diabetics. Some people that are diabetic better tolerate the reason this being the case is fructose. It has also been reported as a folk remedy for diabetes (Levetin and McMahon, 2012), it has a sweet and nutty flavor and a crisp texture when eaten raw, which makes it an interesting culinary ingredient. In addition to tubers being a potential source of biomass, they are known to be a health-promoting food source. It has a large amount of inulin (14-19%) in the tubers as a fructose polymer, and its degraded product oligofructose is the major compound of interest in the food industry as a functional food ingredient. Physiological effects in humans, such as the prevention of diabetes and anti-carcinoma activities, have been reported (Kaur and Gupta, 2002; Pan *et al*., 2009).

Considering these facts, the consumption of Jerusalem artichoke in daily diet may provide supportive actions for a healthier life for consumers. Chips are known as starch and fat-rich products processed generally using extrusion and frying methods. Different studies are being carried out to modify the chips' formulation and processing using various new ingredients, pre-treatments, and cooking technologies to improve the quality and health effects of chips (Lumanlan *et al*., 2020a and b). As a raw material, its consumption is not preferable, and so it is required to be processed into alternative forms, especially like potato products due to similarities in both plant materials. Except for the fact that fried potato products including chips, extruded products, etc., have some potential hazards to health depending on the process conditions and materials and nutritional values of final products, these varieties of commercial items have attracted the high interest of consumers. Jerusalem artichoke has the potential to overcome some of the negative aspects of these varieties of fried products the advances because of compositional and depending on structural differences (Cem and Ali, 2012).

Consumers are demanding high-quality and convenient products with natural flavor and taste, and greatly appreciate the fresh appearance of minimally processed food (Oey *et al*., 2008). To extend the shelf life and keep these products with satisfactory sensory properties, they are usually processed using different methods such as immersing in some aqueous solutions before frying. As well as heating foods' effects on the sensory quality. This is in many cases due to the Maillard reaction that becomes noticeable in heated foods. It affects color, taste, and flavor, but it also has nutritional implications (Seal *et al*., 2008). It was revealed that when compared to Fuseau, the overall yield of the Balady cultivar was much higher as well as the contents of the tubers' dry matter, inulin, and total sugar**.** Regarding the harvest time, data showed that tubers harvested on November 15 had an advantage over those harvested on December 15 in terms of total yield and its components as well as dry matter, inulin, and total sugar contents. Harvest times also play a significant role in the production of high tuber yields (Alian and Attia 2011).

Thus, the objectives of this study were to examine the effect of varieties and harvesting time on yield and quality, chemical composition, and quality of a product like chips.

MATERIALS AND METHODS

The first part of the experiment:

Two varieties of *Jerusalem artichoke* tubers (Balady and Fuseau) were grown during the field experiment conducted in clay soil at Kaha Research Farm in Kaluobia Governorate, Egypt, during two consecutive summer growing seasons of 2018 and 2019. Plants were furrow-irrigated, and tubers were planted on March 15 and April 1 of the 2018 and 2019 summer seasons, respectively. The 20 m^2 experimental unit had two rows that were 1 m wide and 10 m long. 50 cm between tubers was used for planting, to study how different varieties and harvesting dates affect the production, chemical composition, and quality of a chip-like product.

The experiment was created according to "split plots on the randomized complicated block with three replicates**,** harvest times at 240 and 270 days after planting in two seasons were established in the subplot while the two varieties (Fuseau and Balady) were planted in the main plot**.** Composted farmyard manure at a rate of 20 m^3/fed was applied to all treatments. Additionally, conventional advice recommends clay soil conditions using chemical fertilizer were applied.

The following characteristics of all treatments were recorded:

Total and marketable yield (ton fed^{-1}) and total fresh tuber yield (kg/plant) were recorded at 240 and 270 days after planting in two seasons.

Statistical analysis:

Data were statistically evaluated using combined analysis for variance utilizing Statistics software, and the mean values were compared at 5% levels of LSD as recommended by (Snedecor and Cochran, 1980).

The second part of the experiment:

Two varieties of *Jerusalem artichoke* tubers (Balady and Fuseau) were kept in the refrigerator at 4°C until experiments were carried out. The second harvest time was chosen to complete the experiment and conduct all physical and chemical analyses based on the chemical composition of tubers at both harvesting times. All used chemicals were of analytical grade from El-Nasr Pharmaceutical Chemicals Co., Egypt. The used solvents, DPPH (2,2-diphenyl-1-picrylhydrazyl), Gallic acid, and Folin-Ciocalteu reagent were purchased from Sigma Company, (St. Louis, Mo, USA).

Technological methods:

Raw materials were washed under tap water and then tubers were sliced to get pieces having a thickness of 2 mm. The slices were divided into equal five portions and immersed in different aqueous solutions for 5 minutes as follows with the addition of the potatoes as control samples: -

P (Cont.) Potato slices control sample without any treatments.

T1-Balady/ Fuseau slices without any treatments (control).

T2-Balady/ Fuseau slices immersed in 2% acetic acid + 2% sodium chloride solution.

T3-Balady/ Fuseau slices immersed in 1% citric acid + 2% sodium chloride solution.

T4-Balady/ Fuseau slices immersed in 2% acetic acid + 1% citric acid solution.

Frying:

All the previous treatments were fried in a deep fat fryer at two frying temperature degrees (170°C and 180°C) for 240 sec. The Fryer container was filled with 2.5 liters of sunflower oil and four to six slices were immersed in preheated oil at the desired temperature. The fried sample was taken out from the fryer and the remaining oil on the slice surface was removed by a tissue towel (Baltacıoğlu and Esin, 2012) following the frying, a proposed analysis was performed.

Analytical methods:

Chemical analysis:

Fresh Jerusalem artichoke samples at two harvest times were subjected to the following determinations as follows: Moisture, dry matter, protein, ether extract, crude fibers, ash, total and reducing sugars contents were determined according to the methods of (AOAC, 2016), while total carbohydrate contents were estimated by difference. However, fried samples were subjected to the following determinations as follows: Moisture and lipid contents were determined according to the methods of (AOAC, 2016). Both Fresh *Jerusalem artichoke* and fried samples were subjected to determine Inulin content according (Winton and Winton, 1958).

Determination of total phenolic compounds (TPC):

Total phenolic compounds (TPC) were determined by the Folin- Cicalteau method as described by (Singleton *et al*., 1999), with minor modifications. Gallic acid was used for the calibration curve. Results were expressed as mg Gallic acid equivalent (GAE) in mg/100g of dried extract.

Determination of total flavonoids:

Total flavonoid content was determined by using the aluminum chloride colorimetric method, as described by (Chang *et al*., 2002). The results were expressed as catechin equivalent (CE) in mg/100g of dried extract.

Determination of antioxidant activity:

The antioxidant activity of free and bound phenolic extracts was measured by using 1, 1-diphenyl2-picrylhydrazyl (DPPH) scavenging as previously described by (Hung and Morita, 2009).

Color measurements:

The color was determined at three different points of the sample with a Chroma meter (Minolta CR 400, Minolta Camera, Co., Osaka, Japan) equipped with an 8 mm measuring head and a D65 illuminant. The Chroma meter was calibrated using the manufacturer´s standard white plate. Color changes were quantified in the L*, a*, and b* color space. The International Commission on Illumination (CIE) parameters L*, and b* were measured with a (Minolta CR 400, Minolta Camera, Co., Osaka, Japan). The calorimeter was calibrated with a standard white ceramic plate (L = 95.97, a = - 0.13, b = - 0.30) before the reading. Corresponding L* value (lightness of color from zero (black) to 100 (white); a* value (degree of redness (0–60) or greenness (0 to -60); and b* values (yellowness (0–60) or blueness (0 to - 60) were measured for all the samples. Meanwhile, chroma distinguishing between vivid and dull colors was calculated according to (Abonyi *et al*., 2002) by the following equations: - $C^*=\sqrt{a^2 + b^2}$**.**

Texture profile analysis:

Texture measurement of fried Jerusalem artichoke samples was performed 60 min after frying, and drying processes were measured by a Universal testing machine (Cometech, B variety, Taiwan). A punch test was made on the chips, which were mounted over a 3-point-support, where the distance between points was 15 mm, and the punch diameter was 5.3 mm. The crosshead speed was 60 mm/min. Maximum breaking force and deformation were measured from the force-deformation curve, which was recorded using PC software. The probe speed was 1 mm s^{-1}. The Hardness values are expressed in Newton (N), according to Bourne (2002).

Sensory Evaluation:

Sensory attributes (taste, color, crispiness, and overall palatability) of both fried and dried Jerusalem artichoke samples were examined according to the method of (Lindley *et al*., 1993) by using ten members from Horti. Crops Tech. Res. Dept., Food Tech. Research Institute, Agriculture Research Center, Giza, Egypt.

Statistical Analysis:

The statistical analysis was carried out using a one-way analysis of variance (ANOVA) under a significant level of 0.05 for the whole results using the statistical program CoStat (Ver. 6.400) according to (Steel *et al*., 1997). To ascertain the significance among means of different samples, and LSD test was applied.

RESULTS

Effect of variety and harvest times on yield and quality, of Jerusalem artichoke tubers:

Data from Table (1) demonstrated that there are significant differences between the varieties in total yield per feddan over the course of two seasons. Whereas the Fuseau variety exceeded the Balady variety in terms of the total yield of tubers during the two growing seasons and, there was no significant($P \geq 0.05$) effect of harvest times at 240 days after planting and 270 days after planting on total tuber yield ton per feddan. As for, the interaction between varieties and harvest times, Fuseau cultivars that were harvested 240 days after planting and 270 days after planting had a higher total yield of tubers than those produced by Balady cultivars which were harvested throughout the two growing seasons. According to data in Table (1), there were significant effects in the same treatments and interactions between verities and harvest times, where plants of the Fuseau variety produced a higher tuber yield weight of plants compared with the Balady variety in the second season. However, there were no significant differences between the two verities (Balady and Fuseau) and the two harvest times on the yield tubers of plants in the first season only. When compared to other interactions, it was noted that plants of the Fuseau variety that harvested at 27days after planting gave a significant increase in the tuber weight of the plant in the second season only.

However, the results also revealed that there were significant increases in tuber weight in the Fuseau plants' variety when compared to the Balady plant's variety. On the other hand, the results also demonstrated that there are no significant differences between the two varieties, harvest times, and the other interactions on the tuber weight average in the first season. In addition, results in Table (1) showed that there were no significant ($P \geq 0.05$) differences in the tuber weight of Jerusalem artichoke plants at the two harvest times. Referring to the interactions between varieties and the harvest times, data showed that the Fuseau plants variety harvested on the second date produced a higher increase in weight tuber compared to other interactions.

Table 1. Effect of variety and harvest time on total yield and quality of Jerusalem artichoke tubers.

Treat. / Varieties	Total yield ton/Fed		Plant yield Kg/Plant		Tuber weight (g)	
	2018	2019	2018	2019	2018	2019
Balady(B)	14.13^{b}	18.47^{a}	2.22^{a}	2.00^{b}	66.54^{a}	56.10^{b}
Fuseau (F)	23.04^{a}	23.17^{a}	2.92^{a}	2.87^{a}	96.63^{a}	96.00^{a}
Harvest times (HD)						
240 days	19.47^{A}	19.22^{a}	2.41^{A}	2.34^{a}	85,12^{a}	72.55^{a}
270 days	17.60^{A}	22.40^{a}	2.75^{A}	2.53^{a}	77.5^{a}	80.53^{a}
Var. X HD						
BX240 days	14.64^{B}	16.38^{b}	1.70^{A}	1.99^{b}	67.32^{a}	52.37^{b}
B X270 days	13.61^{B}	20.57^{ab}	2.7A	2.00^{b}	65.77^{a}	59.83^{b}
F X1240 days.	24.30^{A}	22.07^{ab}	3.13A	2.68^{a}	89.14^{a}	92.7^{a}
F X270 days.	21.78^{AB}	24.26^{a}	2.71A	3.06^{a}	102.93^{a}	101.23^{a}

Means within the same column followed by the same letters are not significantly different at 5% according to Duncan's Multiple Range Test.

Effect of variety and harvest time on chemical constituents of Jerusalem artichoke tubers:

Data illustrated in Table (2) shows some chemical constituents of two fresh Jerusalem artichoke varieties (Balady and Fuseau) at two harvest times, and the effect of both variety and harvest time on the chemical constituents of two Jerusalem artichoke. The obtained results showed that there were significant ($p \geq 0.05$) differences between both Jerusalem artichoke varieties in the moisture percentage, and the Fuseau variety recorded the higher moisture content, especially at first harvest time.

Table 2. Effect of variety and harvest time on chemical constituents of Jerusalem artichoke tubers (On dry weight basis).

Var.	**Chemical constituents%**											
	Moisture				**Protein**				**Crude fibers**			
	F.H.T.		**S.H.T.**		**F.H.T.**		**S.H.T.**		**F.H.T.**		**S.H.T.**	
B.	81.27^{a}±0.66		77.92^{b}±0.86		2.18^{b}±0.10		2.59^{ab}±0.14		2.86^{a}±0.12		3.06^{a}±0.22	
F.	82.15^{a}±0.93		80.03^{a}±0.97		2.52^{ab}±0.10		2.93^{a}±0.16		2.94^{a}±0.12		3.27^{a}±0.13	
Var.	**B.**		**F.**		**B.**		**F.**		**B.**		**F.**	
	78.98^{b}		81.71^{a}		2.35^{b}		2.76^{a}		2.90^{a}		3.16^{a}	
H.T.	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**
	81.07^{a}	**80.73^{a}**	**83.10^{a}**	**82.01^{a}**	2.07^{a}	2.24^{a}	2.23^{a}	2.58^{a}	2.72^{a}	2.96^{a}	2.93^{a}	3.02^{a}
Var.	**Chemical constituents%**											
	Fat				**Ash**				**T. carbohydrates**			
	F.T.		**S.T.**		**F.T.**		**S.T.**		**F.T.**		**S.T.**	
B	1.76^{b}±0.07		2.07^{a}±0.06		1.12^{a}±0.10		1.36^{a}±0.11		15.79^{a}±0.27		15.87^{a}±0.78	
F.	2.13^{a}±0.08		2.32^{a}±0.08		1.03^{a}±0.08		1.11^{a}±0.10		13.14^{b}±0.87		13.55^{b}±0.64	
Var.	**B.**		**F.**		**B.**		**F.**		**B.**		**F.**	
	1.94^{b}		2.19^{a}		1.24^{a}		1.08^{b}		14.67^{a}		14.51^{b}	
H.T.	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**
	1.62^{b}	1.95^{a}	1.97^{a}	2.16^{a}	1.06^{a}	1.24^{a}	0.98^{a}	1.06^{a}	14.31^{a}	15.26^{a}	11.40^{b}	12.27^{b}

*Values are means of triplicate samples. Means with different letters (a, b, c …) indicate significant differences ($P < 0.05$).

Var. Variety **F.H.T.** First harvest time
B. Balady **S.H.T.** Second harvest time
F. Fuseau **H.T.** Harvest time

On the other hand, the results also showed that there are no clear significant differences in both the effect of harvest time and the interaction between the previous factors on moisture content. While, it was also observed that there were significant ($P \geq 0.05$) differences between both Jerusalem artichoke varieties, as well as, in the interaction between both variety and harvest time on protein percentage, and the Fuseau variety recorded the higher protein content, especially at the second harvest time than at the first harvest time, meanwhile, the results also showed that there are no significant differences in the effect of the harvest time in protein percentage. The obtained results recorded that there were no significant ($p \geq 0.05$) differences in the crude fiber content between the varieties, and the effect of harvest time or interaction between them. However, it was noticed that the Fuseau varieties recorded a higher value, especially at the second harvest time than the Balady variety at the first harvest time. As for, the fat content, the results showed that there were significant differences between each of the understudy varieties. The Fuseau varieties at the second harvest time, as well as the interaction between these two factors, recorded a higher fat content than the Balady variety, also, at the first harvest time.

On the other hand, the results recorded significant differences in ash content between the two understudy verities, the Balady variety at the second harvest time recorded higher ash content than the Fuseau varieties at the first harvest time, while no significant differences were recorded in the effect of harvest time or interaction between them, and the varieties in ash percentage. It was recorded that there were significant differences between both harvest time and Jerusalem artichoke varieties; also, the interaction between them on total carbohydrates percentage and the Balady variety recorded higher carbohydrate content than the Fuseau varieties at the second harvest time.

Effect of variety and harvest time on inulin, total and reducing sugars, phytochemicals contents, and antioxidant activity of Jerusalem artichoke tubers:

By studying the effect of both variety and harvest time on inulin, total, and reducing sugar contents in the two Jerusalem artichoke varieties. The results obtained in Table (3) revealed that there were significant differences between both Jerusalem artichoke varieties, and the Fuseau variety recorded higher content of inulin at the second harvest time compared to the Balady variety at the first harvest time, while, it was noticed that the harvest time or the interaction between both varieties and harvest time did not show significant differences.

Table 3. Effect of variety and harvest time on inulin, total and reducing sugars, phytochemicals contents, and antioxidant activity of Jerusalem artichoke tubers (On dry weight basis).

Var.	**Chemical constituents (%)**											
	Inulin				**Total sugars**				**Reducing sugars**			
	F.H.T.		**S.H.T.**		**F.H.T.**		**S.H.T.**		**F.H.T.**		**S.H.T.**	
B.	$12.12^{a}\pm0.89$		$12.79^{a}\pm0.89$		$31.86^{a}\pm0.82$		$31.97^{a}\pm0.18$		$10.02^{a}\pm0.38$		$8.88^{b}\pm0.29$	
F.	$14.08^{a}\pm0.92$		$14.73^{a}\pm0.78$		$31.94^{a}\pm0.77$		$31.42^{a}\pm0.58$		$8.24^{bc}\pm0.10$		$7.98^{c}\pm0.11$	
Var.	**B.**		**F.**		**B.**		**F.**		**B.**		**F.**	
	13.10^{b}		13.76^{a}		31.90^{a}		31.69^{a}		9.13^{a}		8.43^{b}	
H.T.	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**
	12.32^{a}	12.85^{a}	14.20^{a}	14.78^{a}	31.91^{a}	31.99^{a}	31.48^{a}	31.90^{a}	10.08^{a}	8.81^{b}	8.28^{bc}	7.92^{c}
Var.	**Phytochemical constituents / Antioxidant activity**											
	Total phenolics (mg/g)				**Total flavonoids (mg/g)**				**Antioxidant activity %**			
	F.H.T.		**S.H.T.**		**F.H.T.**		**S.H.T.**		**F.H.T.**		**S.H.T.**	
B.	$30.37^{c}\pm0.08$		$30.65^{b}\pm0.09$		$10.21^{c}\pm0.10$		$10.41^{b}\pm0.10$		$66.66^{b}\pm0.57$		$67.07^{b}\pm0.40$	
F.	$30.59^{b}\pm0.05$		$30.89^{a}\pm0.04$		$10.48^{ab}\pm0.09$		$10.60^{a}\pm0.18$		$85.49^{a}\pm0.72$		$85.80^{a}\pm0.165$	
Var.	**B.**		**F.**		**B**.		**F.**		**B.**		**F.**	
	30.48^{b}		30.77^{a}		10.35^{a}		10.91^{b}		76.23^{a}		77.71^{b}	
H.T.	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**	**F.H.T.**	**S.H.T.**
	30.89^{a}	30.65^{b}	30.59^{b}	30.37^{c}	10.60^{a}	10.48^{ab}	10.41^{b}	10.21^{c}	85.80^{a}	67.12^{a}	67.07^{b}	66.65^{b}

*Values are means of triplicate samples (n =3) Means with different letters (a, b, c …) indicate significant differences ($P < 0.05$).

Var. Variety **F.H.T.** Frist harvest time
B. Balady **S.H.T.** Second harvest time
F. Fuseau **H.T.** Harvest time

On the other hand, it also appeared from the results that there was no significant ($p \geq 0.05$) differences in the effect of the variety, harvest time, or interaction between them in total sugar contents, while it was noticed from the obtained values that Balady variety at second harvest time contains a higher total sugar content than Fuseau variety, while it was found that there were significant ($p \geq 0.05$) differences between the effect of variety and harvest time, as well as the interaction between them on total reducing sugars content, and Balady variety recorded higher reducing sugars content, especially at first harvest time. The recorded results may be due to differences in variety and harvest time. The obtained results also showed in Table (3) the effect of each variety and harvest time, as well as the interaction between them on total phenolic compounds (estimated as gallic acid mg/g) and total flavonoids contents, as well as, antioxidant activity. The Fuseau varieties at the second harvest time recorded higher total phenolic compound contents, as well as both the total flavonoid contents and antioxidant activity, especially at the second harvest time.

Effect of variety, technological treatments, and frying temperatures on physicochemical properties of Jerusalem artichoke chips:

The effect of varieties, technological treatments, and frying temperature degrees on the physicochemical properties of Jerusalem artichoke chips was studied and the data in Table (4) results clearly showed significant differences between the effect of variety and frying temperature, as well as the technological treatments on the moisture content of chips manufactured from both varieties. The Balady variety recorded higher moisture content, especially at 170°C, whereas, the Fuseau variety recorded lower moisture content, especially at 180°C, compared to the potato chips control sample. While no significant differences were observed in the interaction between the previous factors. As for, the effect of the technological treatment on the moisture content of the chips samples under study, it was noted that there were significant differences between the effect of technological treatments, and treatment No. (4) recorded the lowest moisture content, especially for the Fuseau variety, while treatment No. (2) recorded the highest content compared to the comparative potato chips control sample, and it was found that it contains higher moisture content than all technological treatments.

Table 4. Effect of variety, technological treatments, and frying temperature degrees on physicochemical properties of Jerusalem artichoke chips (On dry weight basis).

Var.	Treat.	Physio-chemical properties					
		Moisture%		Oil content%		Hardness (N)	
		170°C	180°C	170°C	180°C	170°C	180°C
P (Cont.)		$5.81^{a}\pm0.17$	$4.73^{a}\pm0.19$	$10.17^{a}\pm0.18$	$11.28^{a}\pm0.38$	$6.74^{abc}\pm0.15$	$7.52^{a}\pm0.21$
B.	T1	$5.50^{a}\pm0.15$	$4.44^{a}\pm0.10$	$4.67^{cd}\pm0.12$	$5.75^{bc}\pm0.12$	$5.64^{cd}\pm0.08$	$7.12^{ab}\pm0.13$
	T2	$5.46^{a}\pm0.09$	$5.27^{a}\pm0.12$	$4.27^{cd}\pm0.06$	$4.67^{cd}\pm0.12$	$6.06^{bcd}\pm0.05$	$6.55^{abcd}\pm0.07$
	T3	$5.35^{a}\pm0.09$	$4.25^{a}\pm0.18$	$3.85^{d}\pm0.07$	$4.97^{bcd}\pm0.14$	$6.26^{abcd}\pm0.06$	$7.15^{ab}\pm0.05$
	T4	$4.63^{a}\pm0.08$	$3.47^{a}\pm0.13$	$3.74^{d}\pm0.05$	$4.84^{bcd}\pm0.12$	$5.52^{cd}\pm0.08$	$6.45^{abcd}\pm0.06$
F.	T1	$3.86^{a}\pm0.12$	$2.74^{a}\pm0.11$	$5.35^{bcd}\pm0.09$	$6.50^{b}\pm0.15$	$5.57^{cd}\pm0.15$	$7.43^{a}\pm0.07$
	T2	$5.85^{a}\pm0.11$	$4.92^{a}\pm0.09$	$5.35^{bcd}\pm0.06$	$6.48^{b}\pm0.14$	$6.46^{abcd}\pm0.13$	$6.56^{abcd}\pm0.09$
	T3	$3.71^{a}\pm0.09$	$2.63^{a}\pm0.12$	$4.47^{cd}\pm0.15$	$5.46^{bcd}\pm0.17$	$5.81^{bcd}\pm0.08$	$6.64^{abcd}\pm0.11$
	T4	$3.55^{a}\pm0.14$	$2.49^{a}\pm0.16$	$4.18^{cd}\pm0.07$	$5.28^{bcd}\pm0.12$	$5.28^{d}\pm0.06$	$6.35^{abcd}\pm0.09$
Var.		B.	F.	B.	F.	B.	F.
		5.05^{a}	3.96^{b}	6.72^{a}	5.62^{b}	6.93^{a}	6.01^{b}
F.T.D.		170°C	180°C	170°C	180°C	170°C	180°C
		5.55^{a}	4.43^{ab}	5.34^{d}	6.44^{b}	6.04^{b}	6.96^{a}
		4.55^{ab}	3.50^{b}	5.90^{c}	7.00^{a}	5.97^{b}	6.90^{a}

Treat.	Moisture%			Oil content%			Hardness (N)		
	P(Cont.)	T1	T2	P(Cont.)	T1	T2	P(Cont.)	T1	T2
	5.27^{a}	4.13^{d}	5.19^{b}	10.73^{a}	5.57^{b}	5.36^{c}	7.13^{a}	6.06^{d}	6.77^{b}
	T3	T4		T3	T4		T3	T4	
	4.49^{c}	3.53^{e}		4.69^{d}	4.51^{e}		6.46^{c}	5.90^{d}	

*Values are means of triplicate samples (n =3) Means with different letters (a, b, c …) indicate significant differences ($P < 0.05$).

Var.: Variety **B.:** Balady **Treat.:** Treatments **F.:** Fuseau **F.T.D.:** Frying temperature degrees

P(Cont.): Potato slices control sample without any treatments. **F1:** Balady/ Fuseau slices without any treatments.

T2-Balady/ Fuseau slices immersed in 2% acetic acid + 2% sodium chloride solution

T3: Balady/ Fuseau slices immersed in 1% citric acid + 2% sodium chloride solution.

T4: Balady/ Fuseau slices immersed in 2% acetic acid + 1% citric acid solution.

The study examined the effect of variety, frying temperature, and technological treatment, as well as the interaction between them on the oil content of the processed chips samples from Jerusalem artichoke varieties. The obtained results revealed that treatment No. (2) recorded the highest oil content in both varieties, while treatment (4) recorded the lowest oil content, especially for the Fuseau variety, at 170°C, compared to the potato chips sample (control), which contained higher content than (10.17-11.28%, at 170 and 180° C, respectively). Also, the effect of all previous factors, as well as the interaction among them, on the degree of hardness of chips samples resulting from Jerusalem artichoke varieties, were studied, (estimated in Newton). The Fuseau variety has a lower degree of hardness, especially for treatment No. (4) at 170°C compared to the Balady variety, while the chips made from potatoes recorded a higher degree of hardness than chips obtained from Jerusalem artichoke varieties.

Effect of the Jerusalem artichoke variety, frying temperature, and technological treatments on the color of Jerusalem artichoke chips:

The illustrated results in Table (5) showed the effect of the Jerusalem artichoke variety and the frying temperatures, as well as the technological treatments on L*- Lightness, b*- Yellowness, a*- Redness, and chroma (vividness) values for chips manufactured from the previous varieties. It appeared from the results shown in Table (4) that the highest values of L * were recorded for Jerusalem artichoke varieties chips (indicating light color) compare to the potato chips control sample, as well as the technological treatment (5,6) in both varieties at 180°C, while it became clear from the obtained results that Fuseau varieties recorded lower (a*) red value than Balady variety and the comparison potato chips control sample, and 180°C.

Table 5. Color measurements of Jerusalem artichoke chips compared to potato chips.

Var.	Treat.	Color parameters							
		L*		a*		b*		Chroma	
		170°C	180°C	170°C	180°C	170°C	180°C	170°C	180°C
	P(Cont.)	41.61	40.10	11.87	10.62	-15.40	-14.22	17.68	16.89
B.	T1	43.83	46.68	11.35	10.57	-17.29	-16.12	12.11	12.03
	T2	46.63	48.21	10.12	10.04	-12.77	-11.65	14.40	14.04
	T3	52.99	55.71	10.17	9.41	-10.95	-9.98	18.12	17.12
	T4	58.05	59.95	10.01	9. 62	-12.68	-11.62	18.68	17.77
F.	T1	46.56	45.65	10.22	9.74	-14.75	-13.75	15.77	15.12
	T2	50.34	55.44	8.69	9.79	-13.69	-12.45	16.21	16.00
	T3	59.39	60.29	9.98	8.76	-6.81	-6.11	16.29	15.38
	T4	61.20	62.18	9.91	8.43	-8.33	-8.02	19.93	18.21

L*: degree of lightness a*: degree of redness b*: degree of yellowness

Var.: Variety **B.:** Balady **Treat.:** Treatments **F.:** Fuseau **F.T.D.:** Frying temperature degrees

P(Cont.): Potato slices control sample without any treatments. **T1:** Balady/ Fuseau slices without any treatments.

T2-Balady/ Fuseau slices immersed in 2% acetic acid + 2% sodium chloride solution.

T3: Balady/ Fuseau slices immersed in 1% citric acid + 2% sodium chloride solution.

T4: Balady/ Fuseau slices immersed in 2% acetic acid + 1% citric acid solution.

On the other hand, the highest b* (yellowness) values were recorded for the Fuseau variety, followed by the Balady variety, then the comparison potato chips sample, at 180°C, moreover, the Fuseau chips sample recorded the highest values of chroma (more vivid yellow color) followed by Balady variety, then the comparison potato chips sample which had more dull yellow color.

Sensory evaluation of Jerusalem artichoke chips:

The scores for sensory evaluation in terms of taste, color, crispiness, and overall palatability were tested and the results were statistically analyzed and illustrated in Table (6). The effect of each variety, technological treatment, and frying temperature on sensory characteristics and overall palatability of the resulting chips from Jerusalem artichoke varieties were studied. It was observed that the high sensory evaluation degrees, as well as the overall palatability, were recorded to Fuseau followed by the Balady variety.

Table 6. Sensory evaluation of Jerusalem artichoke chips compared to potato chips.

Var.	Treat.	Sensory evaluation							
		Taste		Color		Crispiness		Overall palatability	
		170°C	180°C	170°C	180°C	170°C	180°C	170°C	180°C
P (Cont.)		7.50^{a} ±0.50	8.43^{a} ±0.06	7.61^{a} ±0.79	8.60^{a} ±0.10	8.13^{a} ±0.13	8.50^{a} ±0.10	8.25^{abc} ±0.25	8.45^{abc} ±0.05
B.	T1	7.46^{a} ±0.26	8.25^{a} ±0.25	8.61^{a} ±0.25	7.64^{a} ±0.16	7.40^{c} ±0.43	8.17^{abc} ±0.38	8.40^{abc} ±0.50	8.61^{a} ±0.25
	T2	7.50^{a} ±0.25	8.55^{a} ±0.30	8.31^{a} ±0.13	7.62^{a} ±0.08	8.43^{a} ±0.50	8.20^{abc} ±0.25	8.51^{abc} ±0.39	8.31^{a} ±0.13
	T3	7.50^{a} ±0.25	8.51^{a} ±0.25	8.60^{a} ±0.15	7.60^{a} ±0.13	8.51^{a} ±0.13	7.85^{abc} ±0.36	8.63^{abc} ±0.13	8.60^{a} ±0.15
	T4	7.73^{a} ±0.18	8.41^{a} ±0.40	8.65^{a} ±0.30	7.73^{a} ±0.16	8.65^{a} ±0.43	8.50^{abc} ±0.38	8.69^{abc} ±0.50	8.65^{a} ±0.30
F.	T1	8.38^{a} ±0.20	9.07^{a} ±0.07	6.79^{a} ±0.26	7.74^{a} ±0.25	7.50^{c} ±0.50	8.65^{abc} ±0.13	8.65^{abc} ±0.13	6.79^{a} ±0.26
	T2	7.25^{a} ±0.13	8.50^{a} ±0.50	9.51^{a} ±0.50	8.13^{a} ±0.16	8.13^{abc} ±0.16	8.63^{abc} ±0.09	8.55^{abc} ±0.50	9.51^{a} ±0.50
	T3	8.13^{a} ±0.21	7.25^{a} ±0.25	8.13^{a} ±0.13	8.13^{a} ±0.13	9.31^{a} ±0.31	7.75^{bc} ±0.25	9.09^{abc} ±0.09	8.13^{a} ±0.13
	T4	8.50^{a} ±0.66	9.40^{a} ±0.40	9.53^{a} ±0.50	9.16^{a} ±0.25	9.57^{a} ±0.13	9.09^{abc} ±0.13	9.53^{a} ±0.26	9.53^{a} ±0.50
Var.		B.	F.	B.	F.	B.	F.	B.	F.
		7.75^{b}	8.67^{a}	7.89^{b}	8.84^{a}	7.80^{b}	8.70^{a}	8.23^{b}	8.79^{a}
F.T.D.		170°C	180°C	170°C	180°C	170°C	180°C	170°C	180°C
		7.95^{b}	8.86^{a}	8.12^{bc}	9.05^{a}	7.86^{b}	8.85^{a}	8.05^{b}	8.85^{a}
		7.54^{b}	8.48^{a}	7.66^{c}	8.62^{ab}	7.75^{b}	8.54^{a}	8.40^{ab}	8.73^{a}

Treat.	Taste			Color			Crispiness			Overall palatability		
	P(Cont.)	T1	T2	P(Cont.)	T1	T2	P(Cont.)	T1	T2	P(Cont.)	T1	T2
	7.97^{c}	8.38^{b}	7.77^{d}	8.10^{c}	8.66^{a}	8.40^{b}	8.32^{a}	8.45^{a}	8.35^{a}	8.35^{b}	8.43^{b}	8.21^{b}

Treat.	Taste		Color		Crispiness		Overall palatability	
	T3	T4	T3	T4	T3	T4	T3	T4
	8.30^{b}	8.60^{a}	7.97^{d}	8.68^{a}	7.65^{a}	8.49^{a}	8.37^{b}	9.19^{a}

*Values are means of ten samples (n =3). Means with different letters (a, b, c …) indicate significant differences ($P < 0.05$).

Var.: Variety **B.:** Balady **Treat.:** Treatments **F.:** Fuseau **F.T.D.:** Frying temperature degrees

P(Cont.): Potato slices control sample without any treatments. **T1:** Balady/ Fuseau slices without any treatments.

T2-Balady/ Fuseau slices immersed in 2% acetic acid + 2% sodium chloride solution

T3: Balady/ Fuseau slices immersed in 1% citric acid + 2% sodium chloride solution.

T4: Balady/ Fuseau slices immersed in 2% acetic acid + 1% citric acid solution.

Concerning, the effect of both the technological treatments and the frying temperature on the sensory properties mentioned above, the results indicated that there are significant differences between all different technological treatments and the frying temperature degrees. Treatment No. (4) recorded the highest degrees of sensory attributes, as well as overall palatability of both Jerusalem artichoke understudies, especially at 180°C.

As for, the interaction effect of the previous factors, it appeared through the obtained results that there are no significant differences between the values of sensory attributes for all treatments, while the results showed significant differences between the values of overall palatability of all treatments, and treatment No. (4) recorded the highest values for the degree of overall palatability, which indicating that treatment No. (4) is the most desired one.

DISCUSSION

From the obvious results, it was clear that the total yield of tubers and quality were affected by varieties and new clones of Jerusalem artichoke. This result was recorded by Tawfik *et al*. (2003), and Alian and Attia (2011). This variance in results may be due to the genetic material of the two cultivars used in this study. On the other hand, Fuseau cultivars had a higher total yield of tubers than those produced by Balady cultivars which were harvested throughout the two growing seasons. Similar results were reported by Alian and Attia (2011). When compared to other interactions, it was noted that plants of the Fuseau variety gave a significant increase in the tuber weight of the plant in the second season only. These results were according to those reported by Alian and Attia (2011). Whereas it was noticed that there were increases in tuber weight in the Fuseau plants' variety when compared to the Balady plant's variety. On the other hand, the results also demonstrated that there are no differences between the two varieties, harvest times, and the other interactions on the tuber weight average in the first season. Also, in the tuber weight of Jerusalem artichoke plants at the two harvest times. However, the interactions between varieties and the harvest times, data showed that the Fuseau plants variety harvested on the second date produced a higher increase in weight tuber. This increase in tuber weight may because of the environmental circumstances which dominant at the time of harvesting 240 days after planting. The temperature at night and during the day, as well as the length of the day, all contributed to an increase in the yield of tubers. However, the harvesting date 270 days after planting may cause tubers to lose their fresh weight and have lower quality. Similar results were found by (Saengthongpinit and Sajjaanantakul, 2005).

As for, the chemical constituents of two fresh Jerusalem artichoke varieties (Balady and Fuseau) at two harvest times, and the effect of both variety and harvest time on the chemical constituents of two Jerusalem artichoke. The obtained results showed that there were differences between both Jerusalem artichoke varieties at two harvest times, and, on the effect of both variety and harvest time on the chemical constituents**.** These differences in the concentrations of the previous chemical constituents may be due to genetic differences among both Jerusalem artichoke varieties according to Kapusta, *et al*. (2013). The obtained results agreed with those obtained by Neama *et al*. (2020) noted that the Fuseau variety is superior to the Balady variety in protein content, also, Hasnaa (2018) reported that Total carbohydrates are 19.74% protein and 2.19 %, and ash 1.76%.

Concerning the effect of both variety and harvest time on inulin, total, and reducing sugar contents in the two Jerusalem artichoke varieties. The obtained results revealed that there were differences between both Jerusalem artichoke varieties, and the Fuseau variety recorded higher content of inulin at the second harvest time compared to the Balady variety at the first harvest time, while, it was noticed that the harvest time or the interaction between both varieties and harvest time did not show differences. On the other hand, it also appeared from the results that there was no differences in the effect of the variety, harvest time, or interaction between them in total sugar contents, while it was noticed from the obtained values that Balady variety at second harvest time contains a higher total sugar content than Fuseau variety, while it was found that there were differences between the effect of variety and harvest time, and, the interaction between them on total reducing sugars content, and Balady variety recorded higher reducing sugars content, especially at first harvest time. The recorded results may be due to differences in variety and harvest time.

Phenolic substances are secondary metabolites found in horticultural crops that have an antioxidant effect as they scavenge the free radicals caused by oxidative stress (Peretto *et al*., 2017). The obtained results also showed the effect of each variety and harvest time, as well as the interactions between them on total phenolic compounds and total flavonoids contents, and antioxidant activity. The Fuseau varieties at the second harvest time recorded higher total phenolic compound contents, also, both the total flavonoid contents and antioxidant activity, especially at the second harvest time. These differences in the concentrations of total phenolic compounds and total flavonoids may be due to genetic differences among both Jerusalem artichoke varieties according to Kapusta *et al*. (2013). The obtained results were in agreement with those obtained by Neama *et al*. (2020) who noted that the Fuseau variety is superior to the Balady variety in phytochemical, and inulin contents, Alian and Attia (2011), Alian, and Ismail (2014) reported that inulin, total sugar, and reducing sugars of both tubers ranged from (22.15%, 24.21%), (8.64%, 10.03), (22.31%, 23.78%), (6.28%, 10.15%) for Balady and Fuseau varieties, respectively. It is noteworthy that inulin (which belongs to a class of dietary fibers known as fructans) is well fermented by gut bifidobacteria, which contributes to their anticarcinogenic properties. It also induces a 10-fold increase in the Lactobacillus population, which is why it suppresses appetite, regulates the passage rate of digestion, and stimulates the immune system (Michalska-Ciechanowska *et al*., 2019).

The effect of varieties, technological treatments, and frying temperature degrees on the physicochemical properties of Jerusalem artichoke chips was studied, and the results showed significant differences between the effect of variety and frying temperature, as well as the technological treatments on the moisture content of chips manufactured from both varieties.

Oil content is one of the most important quality attributes of a fried product. By studying the effect of variety, frying temperature, and technological treatment, and the interaction between them on the oil content of the processed chips samples from Jerusalem artichoke varieties. The obtained results revealed that treatment No. (2) recorded the highest oil content in both varieties, while treatment (4) recorded the lowest oil content, especially for the Fuseau variety, at 170°C, compared to the potato chips sample (control), which contained higher oil content. The texture is a major factor in determining the customer acceptability of chips and depends on raw materials and processing history. The effect of all previous factors, and the interaction among them, on the degree of hardness of chips samples resulting from Jerusalem artichoke varieties, were studied, and the obtained result show significant differences between both two varieties, also between the treatments. These results may be due to the temperature of frying oil, which raises oil content and increase the degree of hardness. These results agree with those recorded by Cem and Ali (2012), and Habib *et al*., (2015), who ascertained that moisture removal during frying is a key factor for oil uptake. Also, the temperature of 180°C was more oil absorption than at low frying temperature. Moreover, the low frying temperature had a more suitable texture, than the frying temperature at 180°C which had high-fat uptake. Thus, treatment No. (4), the Fuseau varieties and frying temperature at 170°C were better because of low oil content and suitable texture of the crust. Color is a critical factor influencing the quality of the products (Rodríguez-Hernández *et al*., 2005). the results show that the L *, a*, b*, chroma values for Jerusalem artichoke varieties chips compare to the potato chips control sample, and the effect of technological treatment in both varieties at 180°C. were studied, and Jerusalem artichoke varieties chips had good color, also, recorded more vivid yellow color than potato chips sample which had more dull yellow color. These results may be due to using of citric and acetic acids which prevent enzymatic browning, by incapacitating polyphenol oxidase activity and making chips slices crispier and with desirable color. These results agree with Cem and Ali (2012); Vibe *et al*., (2013); Mostafa, *et al*., (2021).

Sensory evaluation is one aspect of greatest importance since consumer acceptance usually encourages the marketing process of any new product. Concerning the effect of each variety, technological treatment, and frying temperature on sensory characteristics and overall palatability of the resulting chips from Jerusalem artichoke varieties the obtained results indicated that there are significant differences between all different technological treatments and the frying temperature degrees. These results may be due to utilizing citric and acetic acids, and the presence of natural aroma volatile compounds some of Jerusalem artichoke varieties are distinctive. These results are in harmony with those of Vibe, *et al*. (2012); Cem and Ali (2012), who reported that Jerusalem artichoke had natural aroma volatile compounds, consequently, the produced chips had a higher score of overall acceptability.

CONCLUSION

In this study, it could be concluded that to obtain higher yield and quality, it is recommended to cultivate the Fuseau variety of Jerusalem artichoke crop and harvest it in mid-January (at 270 days after planting), also, the use of Jerusalem artichoke for the production of diabetic and/or dietary chips-like products was studied using the parameters of variety, frying temperature, and some processing treatment. Considering the experimentally obtained results and their discussion, it can be concluded that Jerusalem artichoke slices could be used to produce low or no-calorie, no-sugar chips, and are most desired by consumers.

REFERENCES

Abonyi, B. I., Feng, H., Tang, J., Edwards, C. G., Chew, B. P., Mattinson, D. S., & Fellman, J. K. (2002). Quality retention in strawberry and carrot purees dried with Refractance Window TM system. *Journal of Food Science*, *67*(3), 1051-1056.

Alian, F. S. S., & Ismail, Sh. A. (2014). Impact of shoots cutting times & the fertilizer equation on growth, productivity, and chemical components of Jerusalem artichoke. *Journal of Biological Chemistry and Environment Science*, 9 (2), 85-99.

Alian, F. S., & Attia, M. M. (2011). Physiological studies on Jerusalem artichoke 1-productivity and quality of jerusalem artichoke in the new reclaimed lands. *Journal of Plant Production*, *2*(12), 1607-1617.

AOAC. (2016). Official Methods of Analysis. 16th Edition, Association of Official Analytical Chemists, Washington DC. Baldini, M., Danuso, F. T. & Vannozzi, M. G. P. (2004). Evaluation of clones of

Jerusalem artichoke (*Helianthus tuberosus* L) for inulin and sugar yield from stalks & tubers. *Industrial Crop and Products,* 19, 25-40.

Cem, B., & Ali, E. (2012). Chips production from Jerusalem artichoke (*Helianthus tuberosus* L.). *Food and Nutrition Sciences*, 3, 1321-1328.

Bourne, M. C. (2002). Food texture and viscosity. Concept & measurement, 2nd Ed. Academic Press, *London*. 427.

Cem, B., & Ali, E. (2012). Chips production from Jerusalem artichoke (*Helianthus tuberosus* L.). *Food and Nutrition Sciences*, *2012*.

Chang, C. C., Yang, M. H., Wen, H. M., & Chern, J. C. (2002). Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *Journal of Food and Drug Analysis*, *10*(3), 178-182.

Glibowski, P., & Wasko, A. (2008). Effect of thermochemical treatment on the structure of inulin and its gelling properties. *International Journal of Food Science and Technology*, *43*(11), 2075-2082.

Habib, O. M., Theodoris, K., Hagar, G., & Frank, F. (2015). Effect of frying temperature on the amount of oil uptake of potato French fries. *MOJ Food Processing and Technology,* 1(1), 17–19.

Taleb, H. M. A. (2018). Evaluation of some products from tartufi (*Jerusalem artichoke*) tubers. *Sciences*, *8*(03), 1011-1023.

Van Hung, P., & Morita, N. (2008). Distribution of phenolic compounds in the graded flours milled from whole buckwheat grains and their antioxidant capacities. *Food Chemistry*, *109*(2), 325-331.

Kapusta, I., Krok, E. S., Jamro, D. B., Cebulak, T., Kaszuba, J., & Salach, R. T. (2013). Identification and quantification of phenolic compounds from Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. *Journal of Food, Agriculture and Environment*, *11*(3/4), 601-606.

Kaur, N., & Gupta, A. K. (2002). Applications of inulin and oligofructose in health and nutrition. *Journal of Biosciences*, *27*, 703-714.

Khuenpet, K., Fukuoka, M., Jittanit, W., & Sirisansaneeyakul, S. (2017). Spray drying of inulin component extracted from Jerusalem artichoke tuber powder using conventional and ohmic-ultrasonic heating for extraction process. *Journal of Food Engineering*, *194*, 67-78.

Levetin, E., and McMahon, K. (2012). *Plants and Society,* 231(101), 2356-2359.

Lindley, M. G., Beyts, P. K., Canales, I., & Borrego, F. (1993). Flavor modifying characteristics of the intense sweetener neohesperidin dihydrochalcone. *Journal of Food Science*, *58*(3), 592-594.

Lumanlan, J. C., Fernando, W. M. A. D. B., & Jayasena, V. (2020). Mechanisms of oil uptake during deep frying and applications of predrying and hydrocolloids in reducing fat content of chips. *International Journal of Food Science and Technology*, *55*(4), 1661-1670.

Lumanlan, J. C., Fernando, W. M., Karnpanit, W., & Jayasena, V. (2021). Effects of food gums and pre-drying on fat content of fabricated fried chips. *International Journal of Food Science and Technology*, *56*(4), 1544-1550.

Michalska-Ciechanowska, A., Wojdyło, A., Bogucka, B., & Dubis, B. (2019). Moderation of inulin and polyphenolics contents in three cultivars of *Helianthus tuberosus* L. by potassium fertilization. *Agronomy*, *9*(12), 884.

Mostafa, M., Fakharany, A., & Abbas, M. (2021). Effect of some treatments of Jerusalem artichoke tubers on the resulted powder for food process uses. *Fayoum Journal of Agricultural Research and Development*, *35*(2), 274-290.

Murphy, O. (2001). Non-polyol low-digestible carbohydrates: food applications and functional benefits. *British Journal of Nutrition*, *85*(S1), S47-S53.

Oey, I., Van der Plancken, I., Van Loey, A., & Hendrickx, M. (2008). Does high pressure processing influence nutritional aspects of plant based food systems?. *Trends in Food Science and Technology*, *19*(6), 300-308.

Pan, L., Sinden, M. R., Kennedy, A. H., Chai, H., Watson, L. E., Graham, T. L., & Kinghorn, A. D. (2009). Bioactive constituents of Helianthus tuberosus (Jerusalem artichoke). *Phytochemistry Letters*, *2*(1), 15-18.

Peretto, G., Du, W. X., Avena-Bustillos, R. J., De J. Berrios, J., Sambo, P., & McHugh, T. H. (2017). Electrostatic and conventional spraying of alginate-based edible coating with natural antimicrobials for preserving fresh strawberry quality. *Food and Bioprocess Technology*, *10*, 165-174.

Rodríguez-Hernández, G. R., González-García, R., Grajales-Lagunes, A., Ruiz-Cabrera*, M. A., & Abud-Archila, M. (2005). Spray-drying of cactus pear juice (*Opuntia streptacantha*): effect on the physicochemical properties of powder and reconstituted product. *Drying Technology*, *23*(4), 955-973.

Saengthongpinit, W., & Sajjaanantakul, T. (2005). Influence of harvest time and storage temperature on characteristics of inulin from Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. *Postharvest Biology and Technology*, *37*(1), 93-100.

Seal, C. J., de Mul, A., Eisenbrand, G., Haverkort, A. J., Franke, K., Lalljie, S. P., Mykkänen, H., Reimerdes, E., Scholz, G., Somoza, V., Tuijtelaars, S., van Boekel, M., van Klaveren, J., Wilcockson, S. J. & Wilms, L. (2008). Risk-Benefit considerations of mitigation measures on acrylamide content of 188 Foods – A case study on potatoes, Cereals, and Coffee. *British Journal of Nutrition,* 99, 1- 46.

Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). [14] Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In *Methods in Enzymology* (Vol. 299, pp. 152-178). Academic Press.

Snedecor, G. W., & Cochran, W. G. (1980). Statistical methods. Iowa State University, Press, Ames. *Iowa, USA*.

Steel, R. G. D., Torrie, J. H., & Dickey, D. A. (1997). Principles and Procedures of Statistics: A Biometrical Approach 3rd Edn p. 246 McGraw-Hill. *New York*.

Tawfik, A. A., Bekhit, R. S., Emara, M. R., Khereba, A. H., & El-Sharkawy, Z. A. (2003). Effect of cultivar and potassium fertilization rate on total yield, chemical constituent and storability of Jerusalem artichoke tubers. *Journal of Plant Production*, *28*(1), 493-512.

Bach, V., Jensen, S., Clausen, M. R., Bertram, H. C., & Edelenbos, M. (2013). Enzymatic browning and after-cooking darkening of Jerusalem artichoke tubers (*Helianthus tuberosus* L.). *Food chemistry*, *141*(2), 1445-1450.

Bach, V., Kidmose, U., Bjørn, G. K., & Edelenbos, M. (2012). Effects of harvest time and variety on sensory quality and chemical composition of Jerusalem artichoke (*Helianthus tuberosus*) tubers. *Food Chemistry*, *133*(1), 82-89.

Winton, A. L., & Winton, K. B. (1958). The Analysis of Foods. John Wiely and Sons Inc. NY.

تأثير الأصناف وميعاد الحصاد على المحصول والتركيب الكيميائي وجودة شبيه الشيبسى الناتج من الطرطوفة

حسن إسماعيل عبد الحكيم[1] *، فاطمة سليمان سلامة عليان[2]

[1] قسم بحوث تكنولوجيا الحاصلات البستانية، معهد بحوث تكنولوجيا الأغذية
[2] قسم بحوث البطاطس والخضر خضرية التكاثر ، بمعهد بحوث البساتين ، مركز البحوث الزراعية، مصر

*بريد المؤلف المراسل:ahi_200526@yahoo.com

تزرع الطرطوفة في مناطق مختلفة وتستهلك على نطاق واسع كغذاء ، حيث تتميز بنكهة مميزة وهى مصدر ممتاز للأينولين والمركبات الفيتوكيميائية وبعض المكونات الوظيفية بما في ذلك الألياف الغذائية والمعادن. تم اجراء هذه الدراسة لتقييم تأثير الأصناف ووقت الحصاد، وعمرالحصاد عند 240 و270 يوم بعد الزراعة (15 ديسمبر و15 يناير) على المحصول الكلي للدرنات طن/فدان وكجم/ للنبات ومتوسط وزن الدرنة وعلى التركيب الكيميائي ، ولاختبار مدى امكانية إنتاج رقائق الشيبسى من صنفين من الطرطوفة وفى موعدين للحصاد والقلي على درجات حرارة مختلفة (170°م ، 180°م) ، وإستخدام بعض المعاملات التكنولوجية.

تم دراسة قيم كلا من التركيب الكيميائي للمواد الخام ورقائق الشيبسى المصنعة ، التغيرات الحسية ، وقيم اللون ، والصلابة ، للمنتج النهائي أظهرت النتائج المتحصل عليها أن صنف فيوزو وميعاد الحصاد الثانى في كمية المحصول الكلي للدرنات ومتوسط وزن الدرنة وكان جيداً في إنتاج رقائق الشبسى مقارنة بالصنف البلدي من حيث مكوناته الكيميائية ، كما يمكن الاستنتاج أن المعاملة رقم(4)(التي تم نقع الشرائح في محلول يحتوي علي 2% حمض خليك و 1% حمض ستريك) وخاصة على درجة حرارة 180°م كانت الأفضل في حفظ العديد من المكونات المهمة ، وكذلك إضفاء خصائص اللون المميزة ، بالإضافة إلى ذلك ، ادت هذه المعاملة الى تحسين صفات الجودة حسية وذلك بناءا على التقييم الحسى لغالبية المحكمين. ومن ثم ، يوصى باستخدام شيبسى الطرطوفة كأطعمة خفيفة.

الكلمات المفتاحية: الطرطوفة، الشبسي، الصفات الفيزيائية الكيميائية.