STUDY ON QUALITY AND SAFETY OF WHITE JERUSALEM ARTICHOKE *(Helianthus tuberosus), FRESHLY HARVESTED, AS SOURCE OF RAW MATERIAL FOR FUNCTIONAL FOOD AND PHARMACEUTICAL PRODUCTS*

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Keywords: Helianthus tuberosus, natural vegetal source cultivated, quality, safety.

ABSTRACT

Within this paper, a study on physical and chemical features of white Jerusalem artichoke tuber's (Helianthus tuberosus) cultivated in Southern Romania, Fetesti, Ialomita, was achieved. The Romanian Plain, where Fetesti locality is situated is characterized by unlimited fields, considered as first- class lands, namely with deep well drained and aerated soil, easy to work, presenting a good permeability and water stocking, with relative high natural fertility for most of plants of culture adapted to climate conditions and which are not difficult to be exploited as arable field. For this study, the tuber vegetal product, in fresh state, was used, being studied samples taken from the vegetal crop established near the road traffic, starting from the half part of cultivated area and from the farthest side, in order to identify the possible pollutant substances acting on minerals, oligoelements, but especially heavy metals contained by it; therefore, not only quality studies, but also complementary studies have been made in order to determine also the safety aspects of this potential source of raw active matter of natural vegetal origin for food industry, functional food, food supplements and pharmaceutical industry.

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus*) , also named „sunroot", „earth apple", or sunchoke is a plant from Asteraceae species, belonging to Helianthus variety. Jerusalem artichoke (topinambour) is culture plant for which the underground tubers are used. The name of topinambour comes from the Amerindian tribe called "Topinambas".

Root of the plant is a rhizome on the root branches, tubers of potato size form, being used for human food and animals foddering. In Europe, the plant may be found as wild state.

Tubers contain inulin, a polymer of fructose with beneficial role in food of diabetics, obese persons by diminishing their appetite, persons who were subject to antibiotics treatments, contributing to restoring of intestinal flora. Inulin also helps to fix the calcium in bones.

Proteins comprised by tubers contain eight (8) essential amino acids: arginine, L-valine, histidine, isoleucine, leucine, lisine, tryiptophan, and phenylalanine.

The leaves contain 4% tryptophan, leucine and beta carotene in a ratio of 45mg/ 100grams. Rhizomes, which represent the plant valuable part, are often used in industry or as fodder, but also as medicine, the active substances from topinambour aiming to adjust blood sugar, cholesterol and digestive microflora.

They also contain iron, calcium, magnesium, manganese, potassium, sodium, silicon, zinc, proteins, pectins, amino acids, vitamins B1, B2 and C, and topinambour is even richer in vitamins B1, B2 and C, than potato, carrot and beetroot by three times.

All vegetal parts of plant (leaves, flowers, tubers, stems) are used in food industry under different forms. Due to its rich content, topinambour is used as immunological, anti-oxidant, anti-toxic, tonic, fortifying and revitalizing element.

In numerous countries of the world (France, Germany, Austria, Ireland, Italy, Spain, Norway, USA, Canada, Brazil, South Korea, Hungary, Yugoslavia, Australia), especially in the last decade, the topinambour research have been developed in different utilization directions.

Areas of utilization: food industry, pharmaceutical industry, and bioenergetics:

- Unique plant thanks to its nutritional values
- Can survive in hard climate conditions, weather variations: 30°C or droughts
- No diseases, minimum care necessary
- interesting taste: slightly sweet, nutty, potato, artichoke like.

Topinambour health benefits:

- Topinambour differs from other types of vegetable by its unique Saccharine system comprising a precious element inulin (up to 20% in dry mater - depends on climatic conditions of growing) and other minerals, vitamins and fibre. Inulin is naturally occurring polysaccharides that is not digested or absorbed in the stomach.
- Detoxifies the body: the role of this undigested part of inulin is to bind and excrete. A large amount of dispensable substances as heavy metals, fatty acids, and other toxic substances that body absorbs with food or are produced during digestion process.

Balanced content of micro-macronutrients

Inulin, as it passes through the small intestine, increases the absorption of vitamins and minerals. From other foods (through the mucosa lining of the intestine into the blood stream) by at least 17%. Other benefits: increases vitality, enhances immunity, low glycemic index, anti - oxidant, gluten- free.

Inulin on a gram - for - gram basis has 62.5% fewer calories than other carbohydrates such as starches, fructose, glucose, and sucrose.

Fig.1 – *Helianthus tuberosus* plant and flower [18]

In drought areas, such as Ialomiţa County, the non-mineralized groundwater situated at small depth leads to soil glazing, swamping, peat adding, even. When groundwater is richly mineralized, then the soil is subject to salinisation.

Taking into account the essential feature of soil, namely fertility that depends on organic waste transformation into humus, the vegetal and animal organisms have a fundamental role in paedogenesis, the other factors representing the conditions in which this process develops. In our country, the two main types of plants, the herbal one and the forest one differently influence the paedogenesis process. As a result of Ialomita county position in plain area, flora and fauna are rather uniform. One of the main characteristics of this area is represented by steppe flora, excepting big rivers' meadows and border areas where forests appear. Bărăgan was the most extended steppe of Romania. In time, it was displaced by plough share and in non-ploughed fields, the primary vegetation is much changed because the excessive pasture.

Herbaceous plants leave into the soil a large quantity of organic waste coming either from plant aerial parts, or, especially from their root system. Due to high temperatures and reduced rainfalls and also to large number of micro-organisms populating the soil, especially bacteria, the vegetal waste breakdown is rather intense. Therefore, when flora is mostly herbaceous, steppe and sylvo-steppe area is characterized by thick bio-cumulative horizon soil rich in high quality humus, reason for which soils in these zones are the most fertile.

Fig.2 – *Helianthus tuberosus* tubercle [19]

Importance of plants growing on the paedogenesis process is also presented by means of roots which have an important impact on soil structure and in general, on protecting it against erosion. Forestry formations generally give a smaller quantity of organic waste than herbaceous ones, mostly coming from leaves that annually fall on soil surface and only a small part coming from roots. By its larger content of substances resistant to decay, the raw organic matter under the forests is qualitatively different from that located under the meadows.

In sylvo-steppe areas in Ialomiţa County, switching between forestry formations and herbaceous ones has determined a specific evolution of organic matter transformation process reflected by the variation of profiles of soil in this region, quantity and quality of humus.

MATERIALS AND METHODS

In SC Hofigal Export Import SA, in order to obtain the dry vegetal product of topinambour (*Helianthus tuberosus*), the fresh vegetal product, after being harvested is subject to the following operations:

- *sorting* fresh vegetal product;
- *washing* the vegetal product;
- *mincing the dry vegetal product*.

Methods of analysis used: all the laboratory analyses were performed according to provisions from European Pharmacopoeia, edition 8.

- For identifying the **MACROSCOPIC CHARACTERISTICS,** a microscopic control of underground organs is performed to establish their type (root, underground stem), as well as the presence or absence of striations, if they are longitudinally or transversally cut, with or without scars, fractures, their colour, etc. Dimensions (length, thickness) are determined in the most developed area of underground organ, by means of a graduated ruler.
- For identifying the **FLAVONOIDS, the following equipment was used***:* water bath and analytical balance, and as *reagents: sodium acetate R, solution 100 g/L; aluminium chloride R, solution 25 g/L; methanol R; ethanol R, solution 50% (V/V); solution test for liquid samples to be analyzed:* at a certain quantity of sample (liquid extracts or tinctures): according to Technical Specification, the product itself is used as *test solution.*
- For identifying **INULIN, the** *equipment used was:* spectrophotometer UV-VIS and as *reagents:* resorcinol solution R 0.09 M in ethanol R(freshly prepared): 9.9g resorcinol R is dissolved in 1000 mL ethanol R; perchloric acid solution R 50 g/L: 42,7 mL perchloric acid R is diluted in1000mL water R; hydrochloric acid R; ethanol R; water R; test solution for solid products (powders, plants, tablets capsules): 0.5g sample to be analyzed are minced in fine particles with 50.0 mL water R at ambient temperature. It is let for 10 minutes, agitating from time to time. Afterwards it is filtered.
- For identifying **POLYPHENOLS, the** *equipment used was:* analytical balance; reagents*: fosfowolframic sodium solution R (Folin reagent):* 10g *fosfowolframic sodium* R, 10 mL phosphorus acid *R and* 75 mL water *R* are heated to boiling temperature under reflux for 2 hours. After having cooled is completed with water *R* at 100 mL; *sodium carbonate R solution 200 g/L*; *ethanol R solution 50 % v/v; test solution*: at a certain quantity of sample to analyze provided in product Technical Specification are added 100 mL *ethanol R solution 50 % v/v* in a large-neck flask and is brought to boiling on water bath, under reflux for 30 minutes. The hot solution is filtered, if necessary.
- For identifying **SUGARS, the reagents used were***:* reagent Feling I: 34.66g copper sulphate R is dissolved in 200 mL water R and completed up to 500 mL with the same solvent; reagent Feling II: are dissolved 173 g potassium and sodium tartrated R and 50 g sodium hydroxide R in 200 mL water R without carbon and is completed up to 500 mL with the same solvent. Before using, equal volumes out of the 2 solutions are mixed; water R, without carbon dioxide: water R is boiled for a few minutes and the vessel is covered for avoiding the contact with atmosphere; test solution: for 1.0 g sample to be analyzed are added 100 mL ethanol R solution 50% (V/V) in a large-neck flask and is heated up to boiling on water bath, under reflux, for 30minutes. Hot solution is filtered.
- For **LOSSES BY DRYING the** *equipment used was:* oven, analytical balance, and as reagents*:* sand R;
- For **TOTAL ASH, the** *equipment was:* calcination oven and as *reagents:* hot water R.
- For determining the **CONTENT OF TOTAL POLYPHENOLS EXPRESSED IN CHLOROGENIC ACID/ CAFFEIC ACID**, the *equipment used were:* analytical balance and spectrophotometer UV-VIS and as *reagents:* sodium wolframate R; phosphoric acid R; water R; fosfowolframic sodium solution R (Reagent Folin: 10 g wolframic sodium R,10 mL phosphoric acid R and 75 mL water R are heated up to boiling temperature, under reflux for 2 hours; after cooling, it is diluted with water R at 100 mL; sodium carbonate solution R 200 g/L; caffeic acid R; standard solutions: solution of caffeic acid R 20 µg/mL, solution of caffeic acid R 30 µg/mL, solution of caffeic acid R 40 µg/mL, solution of caffeic acid R 50 µg/mL, solution of caffeic acid R 60 µg/mL, solution of caffeic acid R 70 µg/mL, solution of caffeic acid R 80 µg/mL, solution of caffeic acid R 90 µg/mL, solution of caffeic acid R 50% v/v, solution of caffeic acid : for

1.0g *sample to be analyzed* are added 100mL *solution of ethanol 50% v/v R*, in a flask with ground-glass stopper and is heated up to boiling temperature, on water bath, under reflux, for 30 minutes. The hot solution is filtered through absorbent cotton in a flask of 100mL and after cooling the solution is completed up to 100mL by washing the residues with *ethanol solution 50% v/v R.*

- For determining the **INULIN CONTENT the** *equipment used was:* a spectrophotometer UV-VIS and as *reagents:* resorcinol R, solution 0.09 M in ethanol R (freshly prepared); hydrochloric acid perchloric acid R; inulin R; perchloric acid R, solution, 5 %; test solution: 0.2 sample to analyze is tritrated with 50.0 mL water R at ambient temperature. It is let to rest for 10 minutes, agitating now and then. It is filtered and diluted at 100.0 mL with water R; stock solution of inulin: 50 mg inulin R are weighed, diluted into water R and brought at 100.0 mL level with the same solvent; reference solution: 0.2 mL test solution, 1.2 mL water R, 1,6 mL perchloric acid R, solution 5 % and 3.0 mL hydrochloric acid R.
- For determining the **CONTENT OF TOTAL SUGAR, the following** *equipment was used:* spectrophotometer UV-VIS and as r*eagents:* solution 1: potassium ferrocyanide ,K3[Fe (CN)6], solution 0.5 N: are dissolved 16.5 g potassium ferrocyanide R at 1 L of water R; solution 2: sodium carbonate, (Na2CO3), solution 1.0 N: 106 g sodium carbonate R are dissolved at 2 L water R; sulphuric acid R, solution 0.8 N; ethanol R, solution 50% (v/v); saturated solution of lead acetate, glucose R; active carbon; reference solution: 2.0 mL water R and 5.0 mL solution 2; solution 3: 2 mL solution 1 are diluted at 100 mL with solution 2. When it is used, the test solution is prepared: In an Erlenmayer glass, a sample of 0.2g is weighed, 50mL ethanol R 50% (v/v) are added and are agitated for 10 minutes. 2-3 drops of saturated solution, lead acetate and one spatula tip with active carbon are added. The sample to be analyzed is filtered in a quoted flask and diluted at100mL with water R.
- For determining the **CONTENT OF REDUCING SUGARS the** *equipment was used:* spectrophotometer UV-VIS and as *reagents:* solution 1: potassium ferrocyanide ,K3[Fe (CN)6], solution 0.5 N:16.5 g potassium ferrocyanide R are dissolved in1000 mL water R; solution 2: sodium carbonate, (Na2CO3), solution 1.0 N: 106 g sodium carbonate R are dissolved in2000 mL water R; sulphuric acid R, solution 0.8 N: 21.4 mL sulphuric acid R are dissolved in1000 mL water R; ethanol R, solution 50% (v/v); saturated solution of lead acetate; glucose R; water R; active carbon R; reference solution: 2.0 mL water R and 5,0 mL solution 2. The mixture obtained is heated in water bath for 25 minutes at 80°C; solution 3:2 mL solution 1 is diluted at 100 mL with solution 2; solution test: In an Erlenmayer glass, a sample of 0.2g is weighed, 50mL ethanol R 50% (v/v) are added and agitated for 10 minutes. 2-3 drops of saturated solution, lead acetate and one spatula tip with active carbon are added. The sample to be analyzed is filtered in a quoted flask and diluted at100mL with water R.
- For determining the **CONTENT OF MINERALS the** *equipment used was:* analytical balance, atomic absorption spectrometer equipped with: cathode-ray lamps as source of radiations, deuterium lamp used as a background correcting device, PC and printer. *Working conditions:* wave length at which the determination is made for different metals is shown in table 1:

Table 1. Wave length at which the determination for different metals is made

Metal	Cadmium (Cd)	Copper (Cu)	Iron (Fe)	Calcium (Ca)	Lead (Pb)	Zinc (Zn)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Manganese (Mn)	Selenium (Se)	Nickel (Ni)	Silicon (Si)	Chrome (Cr)
Wave length (nm)	228.8	324.8	248.3	422.7	217.0	213.9	202.6	589.6	766.5	279.5	196.0	232.0	251.6	357.9

Reagents: hydrochloric acid R, without heavy metals; nitric acid R, without heavy metals; hydrofluoric acid R, without heavy metals; standard solution of respective metals of 1000 ppm; reference solutions: for obtaining the calibration curve, reference solutions of different concentrations are used, being prepared from the standard solution of 1000 ppm, in nitric acid solution 1%, according to table 2:

Table 2. Metal reference solutions

Name	Metal reference solutions (µg/mL, ppm)						
Cadmium (Cd)	0.2	0.4	0.6	1.0	-	-	-
Copper (Cu)	1.0	2.0	3.0	4.0	5.0	-	-
Iron (Fe)	1.0	2.0.	3.0	4.0	5.0	-	-
Calcium (Ca)	1.0	2.0.	3.0	4.0	-	-	-
Lead (Pb)	0.2	0.5	1.0.	1.5	-	-	-
Zinc (Zn)	0.1	0.3	0.5	1.0	1.5	-	-
Sodium (Na)	0.2	0.4	0.6	0.8	1.0	1.2	-
Potassium (K)	0.4	0.6	0.8	1.0	1.2	-	-
Magnesium (Mg)	1.0	5.0	10.0	15.0	20.0	-	-
Manganese(Mn)	0.1	0.2	0.4	0.6	1.0	1.5	2.0
Selenium (Se)	0.5	1.0	2.0	3.0	4.0	5.0	-
Nickel (Ni)	1.0	2.0	4.0	6.0	8.0	-	-
Silicon (Si)	10.0	50.0	100.0	150.0	200.0	-	-
Chrome (Cr)	0.5	1.0	2.0	3.0	5.0	-	-

RESULTS AND DISCUSSIONS

1. Evolution of Helianthus tuberosus culture and obtaining the vegetal product as tuber

Starting with the plant sowing the evolution of culture was monitored in its different moments of growing (fig. 3).

Fig. 3 – *Helianthus tuberosus*

2. Analysis of vegetal product freshly harvested

Den. No.	Characteristics	Results FET -A fresh
1	Macroscopic features	Jerusalem artichoke tubers resulted from heel end, by thickening the underground and final part of the stem, are of black-greyish colour. They are of different size up to 8-9 cm as diameter. They have different shapes, oblong or oblong, being single or grouped by 2-3 at the same place. In crossing section, at the external part we may notice a grey layer made of epidermal cells and the inner content made of additional tissues of white colour.
2	Identification: - flavonoids(chemical reaction) - inulin (chemical reaction) - polyphenols (chemical reaction	 No chemical reaction Is appropriate Is appropriate

	- sugars (chemical reaction)	Is appropriate
3	Drying loss,%, max	66.1
4	Total ash,%, max	1.7
5	Content of total polyphenols expressed in: - caffeic acid,% - chlorogenic acid, %	 0.06 0.12
	- inulin, %	2.92
	- total sugar, %	6.6
	- reducing sugar, %	13.86
	- minerals: Ca Mg Na K Mn Fe Zn Cu Pb Cd Cr	 6.0 14 17 480 <0.1 <0.2 0.6 ND ND ND ND

3. Analysis of samples of vegetal product freshly harvested and taken from three points in culture working depth

3.1. Analysis of samples of vegetal product freshly harvested and taken from crop inner part

Den. No.	Characteristics	Results Jerusalem artichoke tubers inner WHITE
1	Macroscopic features	Jerusalem artichoke tubers resulted from heel end, by thickening the underground and final part of the stem, are of black-greyish colour. They are of different size up to 8-9 cm as diameter. They have different shapes, oblong or oblong, being single or grouped by 2-3 at the same place. In crossing section, at the external part we may notice a grey layer made of epidermal cells and the inner content made of additional tissues of white colour.
2	Identification : - flavonoids(chemical reaction) - inulin (chemical reaction) - polyphenols (chemical reaction) - sugars (chemical reaction)	 No chemical reaction Is appropriate Is appropriate Is appropriate
3	Drying loss ,%, max	77.4
4	Total ash,%, max	0.98
5	Content of total polyphenols expressed in: - caffeic acid,% - chlorogenic acid , %	 0.09 0.17
	- inulin, %	5.69
	- total sugar, %	56.74
	- reducing sugar, %	13.40
	- minerals: Ca Mg Na K Mn Fe Zn Cu	 14.0 16 22 480 ND ND 1.0 ND

	Pb Cd Cr	ND ND ND

3.2. Analysis of samples of vegetal product freshly harvested and taken from the middle of crop

Den. No.	Characteristics	Results Jerusalem artichoke WHITE tubers-in the middle of the crop
1	Macroscopic features	Jerusalem artichoke tubers resulted from heel end, by thickening the underground and final part of the stem, are of black-greyish colour. They are of different size up to 8-9 cm as diameter. They have different shapes, oblong or oblong, being single or grouped by 2-3 at the same place. In crossing section, at the external part we may notice a grey layer made of epidermal cells and the inner content made of additional tissues of white colour.
2	Identification : - flavonoids (chemical reaction) - inulin (chemical reaction) - polyphenols (chemical reaction) - sugars (chemical reaction)	 No chemical reaction Is appropriate Is appropriate Is appropriate
3	Drying loss,%, max	74.4
4	Total ash,%, max	0.5
5	Content of total polyphenols expressed in: - caffeic acid,% - chlorogenic acid, %	 0.07 0.14
	-inulin, %	6.54
	- total sugar, %	48.58
	- reducing sugar, %	9.6
	- minerals: Ca Mg Na K Mn Fe Zn Cu Pb Cd Cr	 12.0 18 25 515 ND ND 1.2 ND ND ND ND

3.3. Analysis of samples of vegetal product freshly harvested from the side part

Den. No.	Characteristics	Results Jerusalem artichoke tubers WHITE taken from the crop side
1	Macroscopic features	Jerusalem artichoke tubers resulted from heel end, by thickening the underground and final part of the stem, are of black-greyish colour. They are of different size up to 8-9 cm as diameter. They have different shapes, oblong or oblong, being single or grouped by 2-3 at the same place. In crossing section, at the external part we may notice a grey layer made of epidermal cells and the inner content made of additional tissues of white colour.
2	Identification : - flavonoids(chemical reaction) - inulin (chemical reaction) - polyphenols (chemical reaction)	 No chemical reaction Is appropriate Is appropriate

	- sugars (chemical reaction)	Is appropriate
3	Drying loss,%, max	77.9
4	Total ash,%, max	1.2
5	Content of total polyphenols expressed in: - caffeic acid,% - chlorogenic acid , %	 0.07 0.14
	-inulin, %	6.0
	- total sugar, %	56.43
	- reducing sugar, %	12.85
	- minerals: Ca Mg Na K Mn Fe Zn Cu Pb Cd Cr	 10.0 14 20 455 ND ND 0.8 ND ND ND ND

CONCLUSIONS

Analyzing the results obtained from the samples of vegetal product freshly harvested, taken from different points on crop surface, the following may be concluded:

A. Fresh product does not generate chemical reaction when identifying with flavonoids, but is appropriate, with positive results by chemical reaction when identifying: inulin, polyphenols and sugar.

B. Total polyphenol content expressed in caffeic acid, % is of 0.06%; total polyphenol content expressed in chlorogenic acid, % is of 0.12; content of inulin is of 2.92 %; content of total sugar, %, is of 6.6 %; content of reducing sugar, %, is of approximately 13.86 %. It has found a very good ratio between the ions of calcium and magnesium ones, in favour of magnesium, as well as between sodium and potassium in potassium favour, the content of mineral salts being relatively small and manganese and iron being present as 0.1 respectively 0.2%, zinc being in percentage of 0.6%.

C. Absence of heavy metals lead and cadmium, that gives not only the product safety but also its quality.

D. Vegetal product Jerusalem artichoke (*Helianthus tuberosus*) cultivated represents an ideal natural source of vegetal origin for raw material related to food and nutrition and medicinal plant with beneficial effects also in economic plan.

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