J. Agric. Sci. Mansoura Univ., 33(11): 7891 - 7903, 2008

PHYSICAL AND FUNCTIONAL PROPERTIES OF JERUSALEM ARTICHOKE FLOUR PRODUCED BY DIFFERENT DRYING METHODS

Abou-Arab,Azza A.;Esmat A. Abou-Arab and Ferial M. Abu- Salem
Dept. of Food Technology, National Res. Centre, Dokki, Cairo, Egypt
E- mail: drazza_nrc@yahoo.com E- mail: Ferial_mas@yahoo.com

ABSTRACT

Physical (pH, color & viscosity) and functional properties (water & oil absorption; foam capacity & foam stability; oil emulsion capacity & stability) of Jerusalem artichoke flour (JAF) produced by different drying methods (sun, oven & microwave) were studied. Measurements of pH values were (5.94), (6.14 to 6.33) and (6.26 to 6.37) with microwave, oven, and sun dried flour, respectively. The L* value (Lightness) were high for different flour comparable to control. The highest mean values of L* were detected in the samples dried by sun (66.66 to 71.57) followed by oven (64.50 to 71.32), and microwave (55.93). Flour prepared by oven drying at 60 °C/7 hr exhibit high viscosity (220 to 319 c.p.). Water and oil absorption capacity of different flour of JA varied considerably depending on the type of treatment and degree of temperature. All treated samples resulted in a significant ($P< 0.05$) increased in water & oil absorption comparing to control. The results of foam capacity & foam stability of the flour didn't show real foam. The emulsifying capacity of the examined treated flour is lower than that recorded with control at the same pH values. The highest mean value of emulsifying capacity was detected with microwave dried samples at pH7.0 (178.4 ml oil/ g sample), however, the lowest was detected in flour dried by sun at 40 °C/72 hr and pH6.0 (110 ml oil/ g sample).
Key words: Physical, Functional properties, Jerusalem artichoke flour, Drying methods.

INTRODUCTION

Jerusalem artichoke *(Helianthus tuberosus*) is a perennial plant, belonging to the family of *Compositae*. Jerusalem artichoke, similar to other perennial plants (dahlia, chicory, etc.) is storing inulin in its tubers as energy providing compound. So the main carbohydrate of Jerusalem artichoke is this polysaccharide, composed as a long polyfructose chain, containing 75 – 85 % of fructose. In the formation of the carbohydrate composition genetic factors, maturity of the tubers and harvesting time are playing a significant role. The polymerization degree of inulin is constantly increasing during the maturing process and decreasing during storage. Degree of polymerization of inulin in completely ripened tubers is max. 35, the same value in developing or stored tubers reaches only 8 - 27 (Barta and Patkai, 2007).

Jerusalem artichoke has very important (action and pharmacology) to control sugar levels, reducing sugar cravings and hypoglycemia. It also, helps to reduce hyperinulinemia and may be useful as a supportive` therapy from non insulin-dependant type II diabetes, which is characterized by elevated insulin levels. Jerusalem artichoke reduces the feeling of hunger and therefore is useful in low-calorie diets to control "the munchies". Finally, it acts as a prebiotic for the good bacteria of intestine, improving nutrient absorption and overall health, consequently from the tubers of Jerusalem artichoke food of very high nutritional value can be produced (dried products; crystallized inulin; purified fructose syrup or natural concentrate, rich in inulin or fructose, containing all natural components of the plant) (Rumessen *et al.,* 1990).

Rhology is defined as the science of the deformation and flow of matters which usually has three aspects: elasticity, viscous flow and plastic flow. On the other hand, the true solutions, exhibit Newtonian viscosity where a direct proportion is observed between the force applied (shear stress) and rate at which the material shears (shear rate)

The composition, temperature and shear rate are important factors determining the viscosity of food. The relationship between viscosity and shear rate can be used to classify foods into Newtonian, non-Newtonian, pseudoplastic, and rheoplasitic (Senol and Esra, 1998).

Functional properties have been defined as any property of a food ingredient, except its nutritional value, that has a great impact on its utilization (Mahajan and Dua, 2002). Hydration properties, water absorption, binding, swelling and viscosity are known to directly influence the characteristics a food system. The functional characteristics of the flour could depend on, among other factors, the type of tuber as well as the handling, treatment prior to flour extraction (Mc Watters, 1983).

The flour-like solid can be used as a starting material for commercial production of fructose and fructooligosaccharides. Both the Jerusalem artichoke flour-like solid and the fructooligosaccharides rich flour-like solid, when mixed with wheat or other flour, can be used in baked foods (e.g. bread and pizza crust). These flours contain considerable amounts of carbohydrates which are fermentable by yeast. Since wheat flour is low in α-amylase, commercial production of leavened products usually requires supplementation of α-amylase or sucrose to yield adequate gassing power of yeast during baking. Use of the flour-like solid from Jerusalem artichoke tubers will reduce the amount of such supplementation. Fructans and fructooligosaccharides in the products will not add calories to a consumers' diet as they cannot be metabolized by humans, but do stimulate growth of "beneficial" intestinal bacteria. Thus, the flour-like solid can be used as an ingredient of foods for people who are prone to obesity, diabetes, constipation, and diseases related to high cholesterol and high blood pressure. The flour-like solid also provides proteins, fiber and potassium which are important dietary components. The flour-like solid ensures availability of these dietary substances to the consumers at reasonable costs ali year-round (Yamazaki *et al.,* 1989).

Available literature of the effect of different drying methods on the physical and function properties of Jerusalem artichoke flour is very rarely, scantly, and needs more studies, so the aim of this investigation was to study the effect of different drying methods at different temperatures on the physical and function properties of Jerusalem artichoke flour produced by three different drying methods (sun-drying, oven-drying and microwave-drying) and the effect of different drying methods on the nutritive value of the Jerusalem artichoke flour and the flour made from Jerusalem artichokes can be used as a functional foods.

MATERIALS AND METHODS

Materials:

1-The Jerusalem artichoke tubers (*Helianthus tuberosus*) that harvested in October, 2007 were provided from the Experimental Station, Agricultural Research Centre, El-Kanater El-Khayria, Egypt.

2- Ascorbic acid were obtained from Sigma Chemical Co. (St. Louis, MO). Corn oil was purchased from local market.

Methods:

All of the tested samples of Jerusalem artichoke tubers were prepared to be dried and converted to flour (powder) as follows:

The samples of Jerusalem artichoke tubers were washed with tap water to remove dust and other undesirable materials. The cleaned tubers peeled and cut into slices. In order to avoid enzymatic browning, the slices have to be brought into contact with hot water immediately. The water can be acidified with ascorbic acid (0.1% w/w) if a very light powder is required and boiling water for 2-3 min. The slices were dried on perforated trays by using the different drying methods and temperatures as follows (Tchone *et al.*, 2005):

a) Control: Jerusalem artichoke tubers without the hot water acidified with ascorbic acid (0.1% w/w) then dried by oven at 40 °C/12 hr.

b) Sun-drying: under conditions as shown in table (1), where one layer of Jerusalem artichoke slices was placed on stainless steel trays and dried at three different temperatures: 40 °C/72 hr, 50 °C/50 hr and 60 °C/36 hr (Modler *et al.*, 1993 and Soliman (2007).

Table (1): Sun-drying conditions of Jerusalem artichoke tubers

Drying conditions	Temperatures /°C		
	40 °C/72 hr.	50°C/50 hr.	60°C/36 hr.
Temperature inside the dryer	40 °C.	50°C	60 °C
Total time for drying	72 hr.	50 hr.	36 hr.
Ambient air temperature	19.4 °C	12.5 °C	26 °C
Relative humidity	57 %	66 %	56 %
Relative humidity inside the dryer	10 %	8 %	10 %
Global solar radiation	845 W/m^2	930 W/m^2	822 W/m^2
Initial moisture content	88 %	88 %	88 %
Final moisture content	5 %	5 %	5 %

c) Air oven-drying: The Jerusalem artichoke tuber slices were placed on stainless steel trays in one layer and then placed on oven and dried at three different temperatures: 40 °C/12 hr, 50 °C/9 hr and 60 °C/7 hr, the trays were removed when the weight of Jerusalem artichoke slices were being constant.

d) Microwave-drying: Microwave oven used in the present study, (Samsung, Model MF245), with oven cavity dimensions of 419 x 245 x 428 mm and operation frequency of 2.450 MHz, with a power source of: 230 V-50 Hz was used. The nominal microwave power out put was 600 W at a medium power level (60 %), air temperature 60 °C /7 min.

The dried slices were milled in cereals mechanical mill to pass through 100 mesh screen sieve. The recovered powder was kept in polyethylene bags and stored at 4 ± 1°C in a refrigerator until used.

Physical analysis of Jerusalem artichoke flour:

Determination of pH value:

The pH value of Jerusalem artichoke powder were measured using pH meter (model CyberScan 500) according to the procedure of Kotula *et al.,* (1976) using one gram of sample flour blended in 25 ml distilled water for 2 min. then filtered through glass wool.

Determination of color:

Color was measured by using a Hunter Lab. Model D25 color and color difference Meter according to Hunter method (1958). This color assessment system is based on the Hunter L*-, a*- and b*- coordinates. L*- representing lightness and darkness, + a*- redness, - a*- greenness, + b*- yellowness and - b*- blueness with white Tile of Hunter Lab color standard: (L= 92.56, a= -0.87 and b= -0.15). Total color difference Δ E was calculated as: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{0.5}$

Determination of viscosity:

The pastes of Jerusalem artichoke flour were prepared for all samples under identical condition as follows: 10 gm of the Jerusalem artichoke flour was dispersed in 100 ml distilled water, stirred for 10 min, and then cooked for 10 min to permit complete starch gelatinization. Viscosity was measured as centipoises (c.p) at 70, 80, 90 and 100 °C using the Brookfield rotational viscometer, using No.4 spindle at 20 rpm. (Model DV III programmable Rheometer U.S.A) at 27.5 °C and at different shear rates (Hayta *et al.,* 2002).

Functional properties of Jerusalem artichoke flour:

Water and oil absorption:

Water and oil absorption were estimated according to Beuchat, (1977). The results were calculated as g water or corn oil (d= 0.92 g/ml) absorbed by 100 g dry sample.

Foam capacity (FC) and stability (FS):

Foam capacity (FC) and foam stability (FS) were determined according to Dipak and Mukherjee (1986). One gram of each sample was whipped with 100 ml distilled water adjusted to a certain pH values, the pH of dispersion for 5 min using an electric blender. FC was expressed as percentage of foam volume remaining in relation to initial foam volume after 5, 10, 20, 30, 40, 60, 90 and 120 min.

Oil emulsion capacity (EC) and stability (ES):

Emulsion capacity (EC) was evaluated in 100 ml of 1% (w/w) aqueous dispersion of each sample at a certain pH values by titration with corn oil until the emulsion collapsed (Marshall *et al.,* 1975). EC was expressed as ml oil emulsified by 1g sample. The emulsion stability (ES) was recorded in terms of percent aqueous phase separated at intervals up to 48 hrs.

Statistical analysis:

Data were subjected to statistical analysis using computerized analysis of variance and Duncan's multiple range test procedures (SAS, 1998). Mean values of three replicates of each test was recorded.

RESULTS AND DISCUSSION

Physical analysis of Jerusalem artichoke flour:

Measurements of pH values in different Jerusalem artichoke flour have shown range levels between 5.94 to 6.66 (Table2). It was surprising that the lowest value of pH (5.94) was detected in flour dried by microwave at 60 °C/7 min. followed by oven dried flour (6.14 to 6.33) and sun dried flour (6.26 to 6.37). On the other hand, the highest pH value (6.66) was detected in dried flour acidification (control). These results are in agreement with those reported by Berghofer and Reiter (1997).

Table (2): pH values of Jerusalem artichoke flour (JAF) dried by different drying methods

Treatments	Temperature °C	pH-values
JAF(control)	40°C/12 hr	6.66
Sun-drying	40°C /72 hr	6.37
	50°C /50 hr	6.26
	60°C /36 hr	6.30
Oven-drying	40°C/12 hr	6.33
	50°C/ 9 hr	6.26
	60°C/ 7 hr	6.14
Microwave- drying	60°C/ 7 min. medium power level (60%).	5.94

Control: drying without ascorbic acid at 40 °C/12 hr.

Color as a matter of visual perception is an important consideration in food product development because food color and appearance are usually the first impressions to register in the consumer's mind. Data in (Table 3) reflected the color quality of the Jerusalem artichoke flour dried by different drying methods. The L* value (Lightness) of different flours were high comparable to control. The acidification results in a clear positive effect, the powders are brighter and slightly yellow.

The highest mean values were detected in the samples dried by sun ranged between (66.66 to 71.57) followed by oven (64.50 to 71.32). However, the lowest L* value was detected for flour dried by microwave (55.93). Regarding to yellow color (a*), (b*), (a/b) and the chroma (c*), results indicated highest values with microwave dried flour compared with the other two methods. On the other hand, these values in dried flour by sun and oven methods were relatively similar. These results are in agreement with those reported by (Berghofer and Reiter, 1997). The color of Jerusalem artichoke flour produced by different drying methods was substantially improved by heating the whole tubers prior to maceration. This serves to inactivate polyphenol oxidase, responsible for the undesirable brown color development (Modler *et al.,* 1993).

Table (3): Hunter color values of Jerusalem artichoke flour (JAF) dried by different drying methods

Treatments	Temperature/ °C	L*	a*	b*	ΔE
JAF (control)	40°C/12 hr	47.80	6.65	21.03	--
Sun-drying	40°C /72 hr	66.66	1.60	14.42	20.61
	50°C /50 hr	71.57	1.81	13.19	25.49
	60°C /36 hr	71.08	1.35	13.45	25.05
Oven-drying	40°C/12 hr	71.32	1.29	14.17	25.08
	50°C/9 hr	64.50	1.57	14.32	18.70
	60°C/7 hr	70.50	1.27	14.77	24.15
Microwave-drying	60°C/7 min. medium power level (60 %),	55.93	7.40	25.14	9.14

Control: drying without ascorbic acid at 40 °C/12 h
L* is the lightness
a* is the red-green color component
b* is the yellow-blue color component
$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{0.5}$

The shear stress response of the Jerusalem artichoke flour dried by different methods (sun, oven and microwave) as well as dried flour without acidification (control) was calculated and used for the analysis of rheological behaviour of the prepared flour samples. From the relations obtained between shear stress and shear rate, values of the viscosity were calculated by dividing shear stress values by the corresponding shear rate values. The results of the calculation were presented in (Table 4) and Figs. (1, 2 and 3).

It was surprising that the relationship between viscosity and shear rate was not linear. On the other hand, the viscosity decreased with increase in temperature degree and shear rate. Heating may rupture the molecular entanglement and bonds, stabilizing the molecular structure and resulting in a decrease in viscosity. As the temperature increases, destabilization of protein interactions occur, which leads to decrease in viscosity (Hayta *et al.,* 2002). Results in (Table 4) indicated that the flour prepared by oven-drying at 60 °C/7 hr exhibit high viscosity (220 to 319 c.p). The reason of this effect seems to be the higher fiber content.

Moreover, the viscosity of oven-drying samples at 40 °C/12 hr and 50 °C/9 hr decreased to (29 - 38 c.p) and (35.5 - 62.4 c.p), respectively. Regarding to sun-drying samples, the viscosity at 40 °C/72 hr was 40.5 - 83.0 c.p increased to (53 - 104 c.p) at 50 °C/50 hr and decreased again to (25.5 - 79.1 c.p) at 60 °C/36 hr., while microwave dried samples was slightly decreased from 49.5 c.p to 36.0 c.p.

Table (4): Dependence of the apparent viscosity (in centipoises) of Jerusalem artichoke flour (JAF) dried by different drying methods

Treatments	Temperature °C	Shear rate (S^{-1})	Shear stress (N/m^2)	Viscosity (c.p)
JAF (control)	70	65.1	31.5	31.5
	80	74.4	31.0	31.0
	90	83.7	28.5	28.5
	100	93.0	26.6	26.6
Sun-drying 40°C /72 hr	70	65.1	51.3	83.0
	80	74.4	37.1	51.0
	90	83.7	35.5	45.5
	100	93.0	30.0	40.5
50°C /50 hr	70	65.1	76.4	104.0
	80	74.4	51.5	70.5
	90	83.7	48.0	56.5
60°C /36 hr	100	93.0	44.5	53.5
	70	65.1	65.5	79.1
	80	74.4	49.5	53.5
	90	83.7	47.5	38.5
	100	93.0	29.5	25.5
Oven-drying	70	65.1	38.0	38.0
	80	74.4	37.0	37.0
40°C/12 hr	90	83.7	33.0	33.0
	100	93.0	30.0	40.5
	70	65.1	62.4	62.4
	80	74.4	51.5	70.5
	90	83.7	37.0	37.0
50°C/9 hr	100	93.0	35.5	35.5
	70	65.1	237.0	319.0
	80	74.4	229.0	313.0
	90	83.7	175.0	236.0
60°C/7 hr	100	93.0	169.0	220.0
Microwave- drying 60°C/7 min. medium power level (60 %)	70	65.1	39.3	49.5
	80	74.4	38.5	46.5
	90	83.7	38.0	38.3
	100	93.0	26.5	36.0

Pastes were prepared at concentration of 10 %, 1p=0.1 p.s.
Control: drying without ascorbic acid at 40 °C/12 hr.

Figs. (1, 2 and 3) show the flow properties of Jerusalem artichoke flour drying by different drying methods at different temperatures. Data revealed that the flow behaviour is following the non-Newtonian pseudoplastic type is sometimes called" shear thinning" which means the product gets thin and viscosity decreased with increasing the shear rates, which the shear stress increased. The decrease in viscosity values could be attributed to the changes occurred in the composition (Senol and Esra, 1998).

Thus Jerusalem artichoke powder could be used as a thickener for non-heated foods. The positive influence on viscosity could allow an additional reduction of the energy content because of savings in sugar or fat. In addition, there is the Bifidus-promoting effect which gives the Jerusalem artichoke powder the character of a functional food technology (Berghofer and Reiter, 1997).

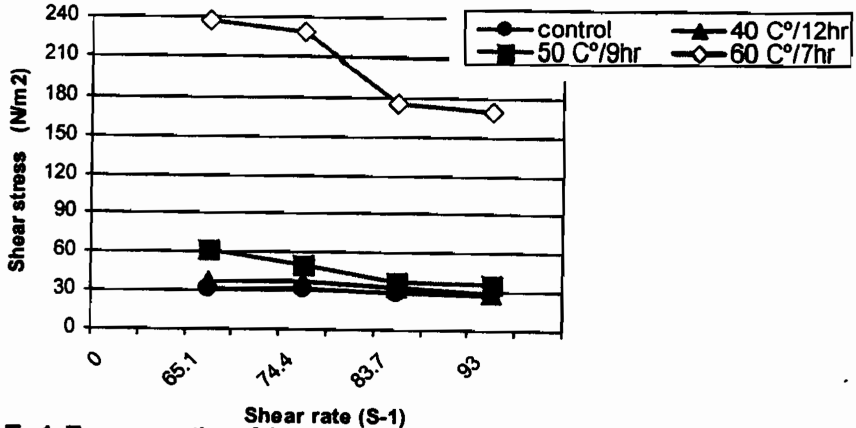

Fig.1. Flow properties of Jerusalem artichoke flour dried by oven at different temperatures

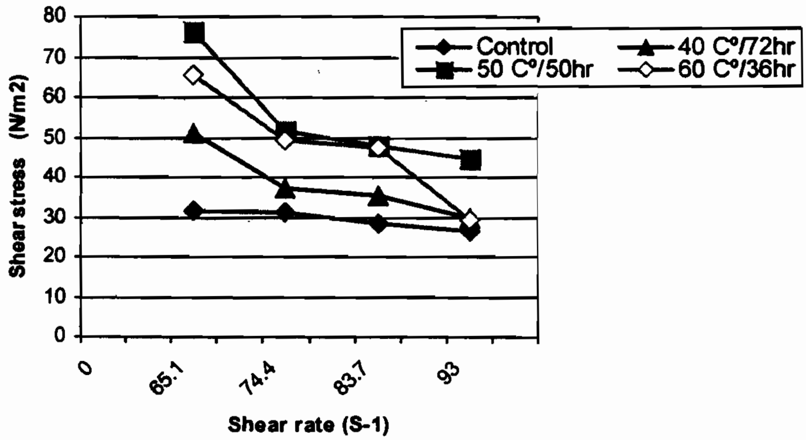

Fig.2. Flow properties of Jerusalem artichoke flour dried by sun-drying at different temperatures

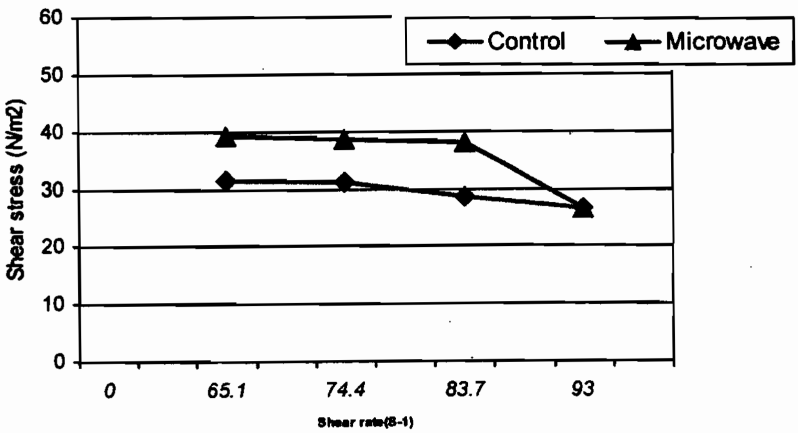

Fig.3. Flow properties of Jerusalem artichoke flour dried by microwave oven

Functional properties of Jerusalem artichoke flour:

Water and oil absorption:

Water absorption capacity (WAC) is considered one of the important functional properties in viscous foods (Hayta *et al.*, 2002) such as sauces dough and baked products. Water and oil absorption of Jerusalem artichoke flour produced by different drying methods was evaluated and the results presented in (Table 5). The current data indicated that the water and oil absorption capacities of different flour of Jerusalem artichoke varied considerably depending on the type of treatment and the degree of temperature. All treated samples (sun-, oven and microwave drying) resulted in a significant (P<0.05) increased in water and oil absorption comparing to untreated sample (control). Regarding to the water oil absorption index (WOAI), results in the same table, indicated significant increase (P<0.05) with sun and oven drying flour, which it was significantly decreased with microwave drying flour comparing with the untreated flour (control). Data also, indicated that the highest mean values of water absorption (614.09 %), and water oil absorption index (6.74 g water/g oil) as well as the lowest value of oil absorption (91.11 %) were detected in the flour dried by oven at 60 °C/7 hr. However, the lowest mean value of either water absorption (274.31 %) and water oil absorption index (2.66 g water/g oil) in the microwave one. On the other hand, the highest mean value of oil absorption (116.24 %) was detected with flour dried by sun at 50 °C/50 hr.

The results obtained indicated that flour preparation by different methods in this investigation can effect on some properties of the flour. Similar results reported by Singh *et al.*, (1991) who showed that the milling equipment and flour preparation methods, such as a milling time can effect on starch, which will result in high water absorption because water can penetrate into granules more easily than intact granules.

Table (5): Water, oil absorption (g/100g dry sample) and water oil absorption index (WOAI) of Jerusalem artichoke flour (JAF) as affected by different drying methods (Mean ± SE)

Treatments	Temperature °C	Water absorption %	Oil absorption %	WOAI (g water/g oil)
JAF (control)	40°C/12 hr	238.69 [h] ± 0.01	77.44 [h] ± 0.015	3.25 [g] ± 0.01
Sun-drying	40°C /72 hr	431.20 [c] ± 0.01	98.31 [c] ± 0.02	4.39 [c] ± 0.01
	50°C /50 hr	386.42 [d] ± 0.01	116.24 [a] ± 0.01	3.32 [f] ± 0.01
	60°C /36 hr	361.04 [f] ± 0.01	96.94 [d] ± 0.01	3.72 [e] ± 0.01
Oven-drying	40°C/12 hr	364.25 [e] ± 0.02	96.09 [e] ± 0.01	3.79 [d] ± 0.01
	50°C/9 hr	437.28 [b] ± 0.01	92.98 [f] ± 0.01	4.70 [b] ± 0.01
	60°C/7 hr	614.09 [a] ± 0.01	91.11 [g] ± 0.02	6.74 [a] ± 0.01
Microwave- drying	60°C/7 min. medium power level (60 %)	274.31 [g] ± 0.01	103.24 [b] ± 0.01	2.66 [h] ± 0.01

Means with the same letter are not significantly different (P<0.05).
Control: drying without ascorbic acid at 40 °C/12 hr.

Foam capacity (FC) and foam stability (FS):

Foam characteristics, i.e. foam capacity (FC) and foam stability (FS) of Jerusalem artichoke flour dried by different methods (sun, oven and microwave) were studied. The results indicated that the all types of flour under investigation didn't show real foam. Some food proteins are capable of forming good foams and their capacity to form and keep stable foams depends on the pH, temperature, and processing methods (Hayta *et al. 2002*).Our results are in agreement with those reported by (Berghofer and Reiter, 1997).

Emulsion capacity (EC) and emulsion stability (ES):

The emulsion capacity and stability of Jerusalem artichoke flour from different dried methods were studied and the results obtained are presented in (Table 6). The emulsifying capacity of the examined treated flour is lower than that recorded with control at the same pH values. The highest mean value of (EC) was detected with microwave dried sample at pH 7.0 (178.4 ml oil/g sample) similar to the EC recorded with control sample at the same pH. The lowest EC was found in flour sample dried by sun at 40 °C/72 hr and pH 6.0 which recorded 110.6 ml oil/g sample).

In the flour dried by sun, EC increased as temperature increased from 40 to 60 °C at pH value 6-7. However, at pH 4.0, EC increased as temperature increased from 40°C/72 hr to 50°C/50 hr. and then declined at 60 °C/36 hr. Regarding to oven drying flour, the same pattern was observed at pH 4.0 and 6.0. In the flour dried by microwave, EC decreased as pH values increased from 4.0 to 6.0, then increased as pH value increased to 7.0. These wide variations in the emulsifying properties of flour at the studied pH range (4.0-7.0) were probably due to differences in their chemical composition.

Concerning the ES of Jerusalem artichoke flour as dried by different methods (sun-, oven and microwave) under the different pH values (4.0, 6.0 and 7.0), the results in Table (6) indicated that the highest stability (ES) was detected with oven dried flour at 50°C/9 hr and pH 6.0 followed by the same treatment at pH 7.0 and oven dried flour at 40 °C/12 hr and pH 6.0. The same stability was detected with sun dried flour at 50°C/50 hr and pH 4.0 as well as oven dried flour at 50°C/9 hr and pH 4.0 which were recorded stability equal the stability of the control.

The emulsifying activity depends on the area of stabilized oil droplets on the interface. Therefore, it is a function of the oil content and the type of equipment used to produce the emulsion (Hayta *et al.,* 2002).The above mentioned data are in close agreement with those previously reported by (Berghofer and Reiter, 1997). All these facts are good reasons for the use Jerusalem artichoke powder.

Finally, it can be concluded that a Jerusalem artichoke powder can be produced by different drying methods such as sun, oven and microwave. The powder could be produced with desired properties depending on the intended use. Physical analysis and functional properties makes the powder useful as a functional food ingredient. It could be used for increasing the dietary fiber content of milk products, sauce, soups, dressings, creams and bakery products.

Table (6): Emulsion capacity (EC) and emulsion stability (ES) of Jerusalem artichoke flour (JAF) as affected b different drying methods under different pH values.

Treatments	Temperature °C	pH values	EC (ml oil/g sample)	ES (% aqu. Phase separated after time, hrs.)						
				0.25	0.50	1.0	2.0	3.0	24.0	48.0
JAF (control)	40°C/12 hr	4	157.0	9	9	12	12	12	21	33
		6	146.3	7	7	11	11	11	19	52
		7	178.4	30	44	47	47	51	51	51
Sun-drying	40°C /72 hr	4	114.2	8	8	10	10	11	20	41
		6	110.6	9	9	11	13	13	40	40
		7	137.4	12	14	25	56	56	56	56
	50°C /50 hr	4	121.3	13	13	20	20	20	33	33
		6	123.1	28	48	48	50	50	62	62
		7	139.2	26	47	47	47	47	47	47
	60°C /36 hr	4	116.0	8	8	10	10	13	50	50
		6	158.8	9	9	20	20	20	53	53
		7	169.5	8	9	12	12	25	38	38
oven-drying	40°C/12 hr	4	105.3	7	7	15	15	26	46	46
		6	115.0	6	7	7	7	7	19	30
		7	159.6	5	6	6	6	6	50	50
	50°C/9 hr	4	124.9	8	8	8	14	14	33	33
		6	133.8	7	7	7	7	7	13	13
		7	140.9	7	7	7	7	7	19	19
	60°C/7 hr	4	112.4	9	9	9	17	17	58	58
		6	130.2	10	11	25	55	62	62	62
		7	167.2	9	8	45	58	65	65	65
Microwave-drying	60°C/7 min. medium power level (60 %)	4	148.0	10	20	20	30	30	32	32
		6	124.9	13	20	40	55	58	66	66
		7	178.4	30	35	41	51	51	51	51

Control: drying without ascorbic acid at 40 °C/12 hr

REFERENCES

Barta, J. and G. Patkai. (2007). Chemical composition and storability of Jerusalem artichoke tubers. Acta.Alim. 36 (2), 257-267.

Berghofer, E. and E. Reiter. (1997). Production and functional properties of Jerusalem artichoke powder. Proceedings of the Sixth Seminar on Inulin Braunchweig Germany Editors:A Fuch's, S. Schittennem, L. Press. November, 14-15. (1996).

Beuchat, L. R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein. J. Agric., Food Chem., 25, 258.

Charley. H. (1970). Food Science, p.430 John Wiley and Sone Inc., New York (USA).

Dipak, K. D. and K. D. Mukherjee. (1986). Functional properties of rapeseed protein products with varying phytic acid contents. J. Agric., Food Chem., 34, 775.

Hayta, M.; M. Alpaslan. and A. Baysar. (2002). Effect of drying methods on functional properties of tarhana: a wheat flour-yogurt mixture. J. Food Sci., 67, 740–744.

Hunter, R. S. (1958). Photoelectric color difference meter. J. O. Pt. Soc. Am. 48 (12): 985, C. F. "Quality Control for the Food Industry", Vol. 1, 1970. Third Edition, P. 31, Kramer, A. and Twigg, B. A. Eds. AVI Publishing Company INC, USA.

Kotula, A. W.; G. G. Twigg. and E. P. Young. (1976). Evaluation of beef patties containing protein, during 12- Month frozen storage. J. Food Sci., 41, 1142-1147.

Mahajan, A. and S. Dua. (2002). Salts and pH induced changes in functional properties of Amaranthus (*Amaranthus tricolour*) L. seed meal. Cereal Chem., 79 (6), 834-837.

Marshall, W. H.; T. R. Duston.; Z. L. Carpenter. and C. Smith. (1975). A simple method of emulsion- end-point determination. J. Food Sci., 40, 896.

Mc Watters, K. H. (1983). Physical and sensory characteristics of Akara processed from cowpea paste and Nigerian cowpea flour. Cereal Chem., 60, 333-336.

Modler, H. W.; J. D. Jones. and G. Mazza. (1993). Observations on long-term storage and processing of Jerusalem artichoke tubers (*Helianthus tuberosus*). Food Chem., 48, 279- 284.

Rumessen, J. J.; S. Bode.; O. Hamberg. and H. E. Gudmand. (1990). Fructan of Jerusalem artichokes: intestinal transport, absorption, fermentation, and influence on blood glucose, insulin, and C-peptides responses in healthy subjects. Am. J. Clin., Nutr., Oct; 52 (4), 675-681.

SAS. (1998). SAS. /STAT User's Guide Release 6.03 edition. SAS Institute Inc., Cary, Nc, USA.

Senol, L. and I. Esra. (1998). Rheological characterization of some traditional Turkish soups. J. Food Eng., 35, 251-256.

Singh, A.; S. Kumar. and I .S. Singh. (1991). Functional properties of jack fruit seed flour. Lebensm – Will u Technology, 24, 373- 374.

Soliman, Marwa, E. E. (2007). Functional and nutritive properties of Jerusalem artichoke (*Helianthus tuberosus L.)* and it's extracted flour. Thesis M. Sc. Degree in Home Economics. Helwan Univ.

Tchone, M.; G. Barweld. and C. Meier. (2005). Polyphenoloxidase in Jerusalem artichoke (*Helianthus tuberosus* L). Br. Food J., 107, (9), 693-701

Yamazaki, H.; H. W. Modler.; I. D. Jones. and J. I. Elliot. (1989). Process for preparing flour from Jerusalem artichoke tubers. U.S.Patent 4871574.

J. Agric. Sci. Mansoura Univ., 33(11), November, 2008

الخواص الطبيعية و الوظيفية لدقيق الطرطوفة المنتج بواسطة طرق التجفيف المختلفة

عزة أنور أبوعرب - عصمت أنور أبوعرب وفريال محمد ابوسالم
قسم الصناعات الغذائية – المركز القومى للبحوث–الدقى –القاهرة–مصر

تم دراسة الخواص الطبيعية (رقم الـ pH واللون واللزوجة) والخواص الوظيفية (القدرة على امتصاص الماء والزيت وسعة وثبات الرغوة وسعة وثبات المستحلب) لدقيق الطرطوفة المنتج بواسطة طرق التجفيف المختلفة (تجفيف شمسي- تجفيف فى الفرن- تجفيف فى الميكروويف).

وقد أظهرت النتائج أن قيم الـ pH كانت ٩٥و٥ , (١٤و٦ – ٣٣و٦), (٢١و٦ – ٣٧و٦) لعينات الدقيق المجففة بواسطة الميكروويف و الفرن والتجفيف الشمسى على التوالى.

كما لوحظ من النتائج أن درجة اللون الأبيض بصفة عامة كانت أعلى فى أنواع الدقيق المختلفة مقارنة بالكنترول. حيث وجد أن أعلى قيم كانت فى عينات الدقيق المجففة بواسطة التجفيف الشمسى حيث كانت تتراوح بين (٦٦و٦٦ -٥٧و٧١) يليه التجفيف بواسطة الفرن (٥٠و٦٤ -٣٢و٧١) ثم التجفيف بواسطة الميكروويف (٩٣و٥٥).

كما أشارت النتائج أن الدقيق المحضر بواسطة التجفيف فى الفرن على ٦٠ م°/٧ ساعات اظهر اعلى درجة لزوجة حيث كانت تتراوح بين (٢٢٠ -٣١٩ سنتيبواز).

وبدراسة الخواص الوظيفية لدقيق الطرطوفة المنتج بواسطة طرق التجفيف المختلفة وجد أن القدرة على امتصاص الماء والزيت تعتمد على نوع المعاملة ودرجة الحرارة. حيث وجد أن القدرة على امتصاص الماء والزيت كانت مرتفعة فى كل العينات المعاملة بالمقارنة بالكنترول أما بالنسبة للقدرة على سعة وثبات الرغوة فانه لم يظهر اى رغوة حقيقية فى جميع عينات الدقيق المختلفة. كما أظهرت عينات الدقيق المعاملة انخفاض فى سعة المستحلب مقارنة بالكنترول على نفس قيم الـ pH.حيث لوحظ أن أعلى قيم للقدرة على سعة ثبات المستحلب كانت لعينات الدقيق المجففة بواسطة الميكروويف على pH ٧ (٤و١٧٨ مللى زيت/ جرام عينة). بينما وجد أن أقل قيم للقدرة على سعة ثبات المستحلب كانت فى عينات الدقيق المجففة بواسطة التجفيف الشمسى على ٤٠ م°/٧٢ ساعة على pH ٦ (٦و١١٠ مللى زيت/ جرام عينة).