Inulin in Some Artichoke By-Products :Determination and Effects of Some Technological Processes Thereon

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ABSTRACT

The present study was conducted to determine the inulin content in some artichoke by - products (biomass) such as leaves, outer and inner bracts and floral stalk beside the edible part of the artichoke head named receptacle in two artichoke cultivars (Balady and French Hyrious) with two sizes from each cultivar (small and large). Generally, French Hyrious cultivar, contained more inulin content as compared to Balady. Data indicated that there were significant differences in inulin content among the different parts of the head in both cultivars and sizes. Meanwhile, Data revealed that the receptacle of artichoke head had the highest percentage of inulin content than the other parts in artichoke head amounted to 41.11% and 52.54% (on dry weight basis) in Balady and French Hyrious, respectively. Blanching in boiling water for different periods (5,10 and 15 min) caused considerable decline in inulin content of artichoke. Cold storage at 5°C decreased the inulin loss of artichoke samples and could not completely inactive the enzyme activity in artichoke. Artichoke samples were frozen at – 22°C and stored for 4 months at –18°C to determine the effect of freezing on inulin content of edible part of artichoke (receptacle). Saoking of artichoke receptacle in 1% citric acid before freezing without any heat treatment could reduce inulin loss during freezing.

Keywords: inulin, globe artichoke, polysaccharides, processing, Cynara scolymus.

INTRODUCTION

Globe artichoke (*Cynara scolymus*, L.) is a perennial plant of the family *Asteraceae* (Compositae). Artichoke is a popular vegetable crop grown in the Mediterranean border, especially Italy, Spain and France, which produce over than 80% of the world crop production (FAO, 2008). This plant had been appreciated by the ancient Egyptians, Greek, and Romans, who used it both as a food and as a medicine (for their beneficial effects against hepato–biliary diseases and as a digestive aid) (Sonnante *et al.*, 2002). The area devoted for its production in Arab Republic of Egypt in 2008, reached about 3800 hectare, which produced approximately 74000 hectogram/ hectare with an average of 19.47 ton/ hectare (FAO, 2008). Globe artichoke still plays an important role in human nutrition, especially in the Mediterranean region. The edible part of artichoke is the immature flower bud, or capitulum (head or choke), which includes the fleshy basis of the outer bracts, the inner bracts, the receptacle and a small portion of the floral stalk. Bigger artichoke heads are not bitter, the smallest which is called "baby" artichoke is the best due to its freshness and tightness. It is, in fact, not immature artichokes. It is worthy mentioned that baby artichokes are not a separate variety but merely smaller versions of large artichokes. Their size comes from their location on the artichoke plant. They are picked from the lower parts of the artichoke plant where the plant fronds protect them from sun, in effect stunting their growth. Baby artichokes are fun because with just a little trimming you can eat whole thing because they haven't developed the fuzzy portion of the choke in the center. The small or large immature flowers harvested in the early stages of their development represent about 30 – 40 % of its fresh weight, depending on the variety and the harvesting time (Lattanzio, 1982).

The edible part of artichoke either small or large is characterized by a high reducing sugar content and a high percentage of water–soluble polysac-

charides (inulin) being 37.00% on dry weight basis, mainly located in the receptacle. The inulin content may represent 75% of the total glucidic content. In addition, the inulin content of the edible portion is relatively higher in artichoke heads of marketable quality as compared to those at earlier stages of development (Lattanzio *et al.*, 2002).

Nutritional and pharmaceutical properties of both artichoke heads and leaves are linked to their special chemical composition, which includes high levels of polyphenolic compounds and inulin. In addition, artichoke, like other members of the *Asteraceae*, synthesizes and accumulates inulin as a major carbohydrate reserve in their storage organs. Inulin molecules with a chain length of up to 200, which is the highest degree of polymerization (DP) of inulin molecules known in plants, are present in artichoke. Inulin belongs to a group of fructose–based polysaccharides called fructans, it is composed of fructose unit chains (linked by (2→1) –β–D–fructosyl–fructose bonds) of various length terminated generally by a single glucose unit (linked by an α–D–glucopyranosyl bond) which are not digested in the small intestine because humans lack the enzymes required for hydrolysis of fructans (French,1993).

A further reason for the recent interest in inulin has been due to the publication of data showing that they positively influence the composition of the gut microflora, and there are indications of beneficial effects on mineral absorption, blood lipid composition, and prevention of colon cancer. The proposed mechanisms include reducing the exposure to mutagens and carsinogens, and suppression of tumour cell survival (Pool–Zobel, 2005). In addition, inulin is a low–calorie fiber that has potential for use in the production of fat–reduced foods (Hellwege *et al.*, 2000). Inulin has been used successfully to replace fat in table spreads, baked goods, fillings, dairy products, frozen desserts and dressings.

Artichoke inulin is moderately soluble in water (maximum 5% at room temperature), it has a bland neutral taste, without any off–flavour or aftertaste, and is not sweet. Therefore, it combines easily with other ingredients without modifying delicate flavours (Lopenz–Molina *et al.*, 2005). Similarly, morphological differences are the main factor determining the inulin content in different cultivars. Although the inulin content in by– products originating from artichoke processing (leaves, external bracts of heads) is more than 30% and being lower than that of the edible part, these by – products could be considered as a promising and cheap source of inulin and fructose.

Nowadays, in Egypt, a great attention is given for promoting globe artichoke production either large or baby to satisfy the increased demands of local fresh market, developing processing industry and rapidly growing exportation. Artichoke by–products such as leaves, external bracts and stems produced by the artichoke processing industry represent a huge amount of discarded materials (about 80–85% of the total biomass produced by the plant), which has the potential as a source of health–promoting inulin and phenolics (Lattanzio *et al.*, 2005).

Information is scarce regarding the inulin content of the different parts of the edible portions of the common globe artichoke cultivated in Egypt. Therefore, the present work aimed to determine the inulin content of some biomass products of artichoke industry to maximize its utilization to produce inulin. Moreover, the work aimed to investigate the effect of some technological processes on inulin content of the artichocke.

MATERIALS AND METHODS

Materials

Artichoke heads of French Hyrious and Balady (local) cultivars were obtained from private farm located at Shamal El– Tahreir, Behiera Governorate, Egypt. Heads of both cultivars were harvested at two sizes; small (25 days after blooming "flower bud initiation") and large (40 days after blooming) sizes. Heads of each size were almost homologous in colour and were free from mechanical damages and defects. Heads were brought, as soon as possible, after harvest to the pilot plant of Food Science and Technology Department, Faculty of Agriculture, Alexandria University, Egypt. Each head belonging to each size was divided into five parts, the leaves formed on the floral stalk (A), a small portion (15 cm) of the floral stalk (pedicle) (B). the upper parts of the outer and inner bracts (C), the receptacle (D), and the fleshy outer and inner bracts(E) , as shown in Fig. (1).The samples were kept in polyethylene bags at room temperature (22±2°C) until used for subsequent inulin extraction.

Methods:

Technological methods

Receptacle parts were used to study the effect of some processing methods such as blanching, cold storage and freezing on inulin content of artichoke,

since the receptacle has the highest content of inulin as compared to the other parts under study.

The effect of blanching was carried out in boiled water at 100°C for 5, 10 and 15 min, followed by rapid cooling.

The effect of cold storage on inulin content was studied by storing samples in a refrigerator at 5°C and relative humidity about 87%, whereas, the control samples were stored in the laboratory at (22±2°C) and relative humidity about 65–75% . Storage was continued until samples became dry and unfit for consumption.

Freezing at –22°C using multiplate freezer was carried out for each of the following samples:–

a– The control samples without any treatment.

b – Blanched samples (blanching was carried out at 100°C for 5 min, cooling) to inhibit peroxidase (Reid, 1996).

c– Soaked samples in 1% citric acid for 10 min, to minimize browning (Tressler & Evers, 1968).

The aforementioned frozen samples were stored for 4 months at –18°C .

Chemical methods:

Inulin extraction

Inulin was extracted by hot deionized water according to the method of Van Waes *et al.*, (1998) with some modifications. Eighty–five ml of deionized water at 85°C were added to 11.5g crushed sample, and the slurry was shaken at 130 rpm at 85°C for 1 hr in a water bath. After cooling to room temperature, the total weight was adjusted to 100 g with deionized water,and the slurry was then centrifuged for 20 min at 12,000xg. The supernatant was stored at –18°C until the determination of inulin .

Acid hydrolysis of inulin

One hundred mg of pure inulin (BDH, U.K.) were dissolved in 50 ml distilled water, transferred to 100 ml volumetric flask, five ml 25% HCL were added and heated at 70°C for 15 min in a water bath. Immediately, the hydrolysate was cooled to 20°C, adjusted to pH 7 with 50 % NaOH w/w. Finally, it was diluted to 100 ml with distilled water. The hydrolysate inulin extracts were analyzed for fructose within 24 hr.

Determination of inulin

The colouromertric dinitrosalicylic acid (DNSA) method (Plummer,1978) was used for determining the hydrolysed inulin as fructose. Two milliliters of sample were added to 50 ml test tube containing 2 ml of the DNSA reagent (0.25g 3,5– dinitrosalicylic acid was dissolved in a mixture of 5ml 2 N NaOH and 12ml water, 7.5g potassium sodium tartrate, were dissolved in the mixture and diluted to 25ml with water). The tubes were placed in boiling water bath for 10 min, cooled, and then 1 ml of water was added to each tube. The absorbance was measured at 540 nm using the Spectrocolorimeter (Carl Zeiss–Jena). Standard curve of fructose was carried out following the same procedure. The inulin content of the sample was calculated as follows:

% Inulin in sample = % fructose after hyrolysis – % fructose before hydrolysis × 1.098.,

where 1.098 is a correction recovery factor for standard inulin.

Detection of peroxidase

The test for adequacy of blanching before freezing was applied as described by Cobey & Manning (1953) using H_2O_2 as a substrate and guaiacol as an oxygen acceptor. No colour change is considered as negative ; a reddish colour is considered slightly positive and a deep reddish brown colour is considered as positive.

Moisture content was determined according to the method described in the AOAC (1995) using dry air oven.

Statistical procedures

The f–test, and analysis of variance of treatments difference were performed according to Steel &Torrie (1980). Statistical analysis was done by, ANOVA (three ways interaction), f–test, and L.S.D procedures available within the SAS software package (9.0, 2004).

RESULTS AND DISCUSSION

Effect of variety and size on inulin content of artichoke

The results presented in Table (1) show that inulin was found in all parts of the different head sizes of globe artichoke cultivars. Data, also, indicate that there were significant differences in inulin contents among the different parts of head in both sizes and cultivars. Generally, French Hyrious cultivar, irrespective the head size, contained more inu-

lin content as compared to the Balady one. Meanwhile, the large heads, of the two tested cultivars, had higher inulin content than those of the small heads regardless the different parts of the head. It was also noticed that the large heads of French Hyrious cultivar showed higher inulin content (52.54% on dry weight basis) than those of Balady cultivar (41.11% on dry weight basis). So, it was observed that , in the large head of both cultivars, the receptacle contained the higher content of inulin , followed by the upper parts of the outer and inner bracts, then the floral stalk (pedicle) ,then the fleshy outer and inner bracts, whereas, the leaves formed on the floral stalk occupied the last position.

On the other hand, the different parts of small heads belonging to Balady cultivar contained more inulin content (approximately double mean values) than those of the small ones of the French Hyrious cultivar, with the exception of the leaves formed on the floral stalk.

Whereas the small heads in both cultivars, the fleshy outer and inner bracts ranked the third after the receptacle and the upper parts of the outer and inner bracts . The leaves formed on the floral stalk occupied the last position in Balady cultivar but the floral stalk was the last position in French Hyrious variety. These results agree with those of Lattanzio *et al.* (2005) who reported that inulin content in by–products originating from artichoke processing (leaves, external bracts of heads) is more than 30% and being lower than that of the edible part, and thereby these by–products could be considered as a promising and cheap source of inulin and fructose.

Effect of blanching on inulin content of artichoke

The data in Table (2) show that blanching of artichoke heads in boiled water at 100°C had significantly lowered the inulin content. After 5 min of blancing, the percentages of inulin loss being, 25.70, 46.20, 31.80 and 33.10% in small and large size of Balady and French Hyrious artichoke, respectively. This means that , heat treatment has a negative effect on inulin content because inulin dissolves in hot water (Van Waes *et al.*, 1998). It was obvious

Table 1: Inulin content (on dry weight basis) of some artichoke parts (by – products)

Part	Cultivar			
	Balady		French Hyrious	
	small	Large	small	Large
(A)	$2.93^{m}\pm0.03$	$3.36^{lm}\pm0.21$	$4.24^{lm}\pm0.23$	$4.83^{kl}\pm0.1$
(B)	$8.93^{j}\pm0.36$	$14.44^{gh}\pm0.6$	$2.96^{m}\pm0.18$	$20.55^{e}\pm0.76$
(C)	$27.62^{d}\pm0.2$	$28.99^{d}\pm0.13$	$13.98^{hi}\pm0.54$	$40.88^{b}\pm1.2$
(D)	$31.49^{c}\pm0.58$	$41.11^{b}\pm0.84$	$16.84^{f}\pm1.23$	$52.54^{a}\pm1.8$
(E)	$12.80^{hi}\pm0.35$	$13.22^{hi}\pm0.32$	$5.88^{k}\pm0.58$	$15.70^{fg}\pm1.8$

(A) The leaves formed on the floral stalk. (B) Floral stalk (pedicle).
(C) The upper parts of the outer and inner bracts. (D) Receptacle.
(E) Outer and inner bracts.
Means in a column or row not sharing the same manuscript are significantly different at $P \leq 0.05$

Table 2: Effect of blanching on inulin content of Balady and French Hyrious cultivars globe artichoke

Blanching period (min)	Balady				French Hyrious			
	Small		Large		Small		Large	
	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)
0	$31.49^{d}\pm 0.69$	——	$41.11^{b}\pm 0.84$	——	$16.84^{g}\pm 0.23$	——	$52.54^{a}\pm 1.8$	——
5	$23.54^{e}\pm 0.44$	25.70	$22.12^{ef}\pm0.7$	46.20	$11.48^{h}\pm 0.62$	31.80	$36.46^{c}\pm 0.16$	33.10
10	$19.35^{fg}\pm 0.55$	38.50	$21.52^{ef}\pm0.1$	47.70	$9.90^{h}\pm 0.79$	39.90	$32.45^{d}\pm 0.05$	40.50
15	$17.78^{g}\pm 0.58$	43.50	$21.18^{ef}\pm0.9$	48.50	$9.70^{h}\pm 0.27$	41.80	$30.03^{d}\pm 0.89$	44.90

* On dry weight basis
Means in a column or row not sharing the same manuscript are significantly different at $P \leq 0.05$

that the loss of inulin from artichoke head due to blanching was significantly influenced by both variety and size of the heads. In other words, considerable differences could be traced in terms of inulin loss from small and large size belonging to the two cultivars under study. Meanwhile, elongation of blanching period from 10 to 15 min resulted in elevation of inulin loss. The percentages of inulin loss were, 38.50, 47.70, 39.90 and 40.50% after 10 min of blanching and 43.50, 48.50, 41.80 and 44.90% after 15 min of blanching of small and large Balady and French Hyrious artichoke, respectively.

Effect of cold storage on inulin content of artichocke

Table (3) shows the impact of cold storage at 5°C on the percentage of inulin content in artichoke as compared with the control which was kept at room temperature (22±2°C). A clear impact of the cold storage could be figured out in reducing the loss of inulin after the first week from 54.90, 57.14, 61.50 and 42.90% in the control samples (22°C) to 10.86, 20.26, 5.70 and 21.00% in cold samples (5°C) in both small and large size of Balady and French Hyrious cultivars, respectively. After second week of storage, an effective increasing in inulin loss was noticed in the control samples as compared with the cold samples where the percentages of inulin loss were 75.19, 78.30, 84.00 and 82.60% in the control samples and 25.00, 34.15, 11.50 and 40.00% in cold samples in small and large size of both cultivers Balady and French Hyrious, respectively. After three weeks of storage, the control samples lost its freshness and being unacceptable for consumption whereas the cold samples maintained its freshness and relatively exhibited good quality although the loss of inulin content reached to 32.64 and 40.38% in small and large size of Balady and 21.00, 41.11% in small and large size of French Hyrious cultivar. This means that cold storage minimised the enzyme activity and inulin loss. The results indicated that the size had a significant effect on inulin loss of artichoke because the percentages of loss in large size were higher than those of small size in both cultivars. This perhaps may be attributed to the increase in enzyme activity in the large size of artichoke as compared with small one.

Effect of storage on inulin content of frozen artichoke

Table (4) illustrates the effect of freezing process at –22°C and storage for four months at –18°C on inulin content of Balady globe atrtichoke , after applying two different treatments prior to freezing (blanching for 5 min at 100°C and soaking in 1% citric acid for 10 min) comparing with the control sample (without treatment). Significant differences in the inulin loss could be noticed among the different frozen samples during storage period. There was a gradual increase in the percentage of inulin loss in all frozen samples after one month of storage. The percentages of inulin loss were, 15.50 and 27.00% in the small and the large sizes of the control samples respectively, after storage for one month. It was noticed that the blanching in boiling water caused more pronounced loss in inulin content of both the small and the large sizes (26.00, 48.00%) as compared to the other samples. From the results in Table (4) it was observed that the soaking of artichoke receptacle in 1% citric acid before freezing decreased the loss in inulin content of artichoke samples. The percentage of loss reached 2.50% and 5.50% for small and large size, respectively. After four months of storage, the percentages of inulin loss increased rapidly and reached to 32.00% in the small size and 53.00% in the large size of the control samples. In case of the blanched samlpes, the percentages of inulin loss showed moderate increase during storage, it increased from 26.00 to 35.00% in the small size and from 48.00 to 52.90% in the large size after four months of storage. This perhaps could be attributed to the high solubility of inulin compound in hot water during blanching or due to inactivation of enzymes in the control before freezing .The samples which have been soaked in citric acid before freezing lost only 9.50% of its inulin content in the small size and 13.90% in the inulin content of the large size after four months of storage .The results in Table (5) show the inulin loss in frozen French Hyrious globe artichoke during storage for four months. The results indicate the same trend as obtained in the Balady cultivar. It was noticed that there was a gradual increase in the inulin loss of all frozen samples during storage period , extending storage period to four months caused a significant decline in the inulin content of the control and the blanched samples. Meanwhile the samples which soaked in citric before freezing showed a little loss in inulin content. The percentages of inulin loss in the small size of the control samples increased from 16.00% after one month of storage to 47.50% at the end of storage period and from 30.60 to 53.30% in the

Table 3: Effect of cold storage on inulin content of Balady and French Hyrious cultivars globe artichoke

Period (Weeks)	Balady								French Hyrious							
	Control				cold storage				Control				Cold storage			
	Small		Large		Small		Large		Small		Large		Small		Large	
	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)
0	31.49^{e}±0.69	——	41.11^{b}±0.52	——	31.49^{e}±0.69	——	41.11^{b}±0.84	——	16.84^{hi}±0.65	——	52.54^{a}±1.8	——	16.84^{hi}±1.2	——	52.54^{a}±1.8	——
1	14.20^{i}±0.82	54.90	26.16^{def}±0.9	57.14	28.10^{cde}±0.92	10.86	32.78^{c}± 0.58	20.26	6.48^{jk}± 0.75	61.50	29.98^{cd}±0.73	42.90	15.88^{i}±0.52	5.70	41.50^{b}± 0.91	21.00
2	7.81^{j}±0.73	75.19	8.92^{j}± 0.82	78.30	23.61^{fg}±0.75	25.00	27.10^{cdef}±0.88	34.15	2.70^{k}±0.13	84.00	9.11^{j}± 0.42	82.60	14.90^{i}± 0.55	11.50	31.49^{c}±0.87	40.00
3	——	——	——	——	21.21^{gh}±0.92	32.64	24.50^{efg}±0.8	40.38	——	——	——	——	13.30^{i}±0.18	21.00	30.94^{cdef}±1.6	41.11

* On dry weight basis Control = 22 °C Cold storage = 5°C

Means in a column or row not sharing the same manuscript are significantly different at P ≤ 0.05

Table 4: Effect of storage on inulin content of frozen Balady globe artichocke cultivar

Freezing period (Months)	Control				Blanching				Soaking in 1% citric acid			
	Small		Large		Small		Large		Small		Large	
	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)
0	31.49^{e}±0.69	–	41.11^{a}±0.52	——	31.49^{e}±0.69	——	41.11^{a}±0.84	——	31.49^{e}±0.69	——	41.11^{a}± 0.84	——
1	26.60^{de}±0.46	15.50	30.01^{cd}±0.98	27.00	23.30^{e}±0.95	26.00	21.37^{ef}±0.67	48.00	30.70^{e}±0.27	2.50	38.89 ^{ab}± 1.8	5.50
2	23.61^{de}±0.46	25.00	27.13^{d}±0.73	34.00	22.13^{ef}±0.9	29.70	20.34^{ef}±0.22	50.50	29.38^{cd}±1.1	6.70	38.88^{ab}± 1.1	5.90
3	22.67^{ef}±0.94	28.00	24.30^{de}±0.92	41.00	20.94^{ef}±0.9	33.50	20.14^{ef}±0.82	51.00	29.00^{d}±0.92	7.90	37.61^{ab}± 1.4	8.50
4	21.4^{ef}±0.85	32.00	19.32^{f}±0.86	53.00	20.49^{ef}±0.93	35.00	19.40^{f} ±0.96	52.90	28.49^{cd}±0.54	9.50	35.39^{b} ±0.64	13.91

* On dry weight basis

Means in a column or row not sharing the same manuscript are significantly different at P ≤ 0.05

Table 5: Effect of storage on inulin content of frozen French Hyrious globe artichoke cultivar

Freezing period (Months)	Control				Blanching				Soaking in 1%citric acid			
	Small		Large		Small		Large		Small		Large	
	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)	Inulin* (%)	Loss (%)
0	16.84 ^{f}±1.2	——	52.54^{a} ±1.8	——	16.84^{f}±0.65	——	52.54^{a}±1.8	——	16.84^{f}±0.65	——	52.54^{a}±1.8	——
1	14.14 ^{fg}±0.65	16.00	36.50^{c}±0.29	30.60	12.10^{g}±0.82	28.00	34.15^{cd}±0.72	35.00	16.21^{f}±0.44	3.70	50.49^{ab}±0.57	3.90
2	11.20 ^{gh}±0.54	33.60	35.30^{c}±1.2	32.80	11.90^{g}±0.32	29.00	33.73^{cd}±0.96	35.50	16.00^{f}±0.82	5.55	49.12^{ab} ±0.94	6.50
3	10. 66 ^{gh}±0.32	36.60	33.20^{cd}±0.88	38.70	11.85^{g}±0.82	29.50	32.31^{cd}±0.9	38.50	16.01^{f}±0.77	5.00	47. 86^{b}±1.2	8.90
4	8.28 ^{h}±0.62	47.50	24.50^{e}±0.65	53.30	10.97^{gh}±0.62	35.00	30.90^{d}±0.97	41.00	14.91^{fg} ±0.88	11.50	44.44^{b}±1.2	15.40

* On dry weight basis

Means in a column or row not sharing the same manuscript are significantly different at P ≤ 0.05

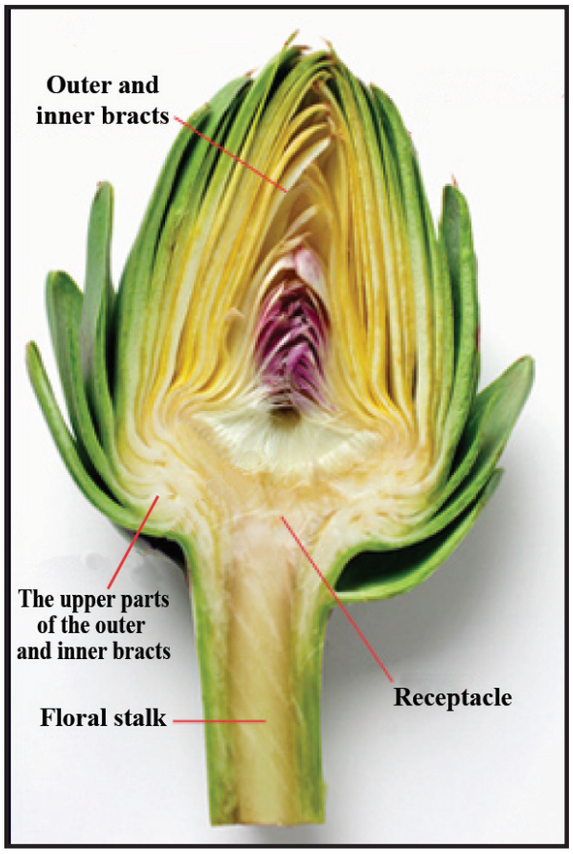

Fig. 1: Vertical section in artichoke head illustrates study parts

large size of frozen artichoke .The blanched samples showed a noticeable increase in the inulin loss within storage period. The percentages of inulin loss of small and large size increased from 28.00 and 35.00% after one month of storage to 35.00 and 41.00% after four months of storage. Samples soaked in citric acid occupied the last position in inulin loss, whereas the percentages of inulin loss were 3.70, 3.90% after one month of storage and reached to 11.50, 15.40% after four months of storage of small and large size, respectively. From the previous results, it could be concluded that, there was a gradual significant increment in inulin loss during storage of frozen artichoke, the inulin loss were more pronounced in the large size of the two artichoke cultivars as compared with the small one, furthermore, blanching of the artichoke receptacle before freezing caused a noticeable loss in inulin content of frozen samples during storage period, while soaking of artichoke samples in 1% citric acid before freezing had a significant impact in reducing of inulin loss during storage period.

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الإنيولين فى بعض النواتج الثانوية للخرشوف: التقدير ومدى تأثره ببعض المعاملات التكنولوجية

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أجريت هذه الدراسة باستخدام صنفين من أصناف الخرشوف هما الصنف البلدى و الصنف الفرنساوى مع استخدام حجمين من كل صنف (الحجم الصغير والحجم الكبير) وذلك لتقدير نسبة الإنيولين فى بعض أجزاء الخرشوف المستبعدة خلال عمليات إعداد الخرشوف للتصنيع وهى أوراق النبات الخارجية و العنق والأوراق الخارجية و الداخلية لنورة الخرشوف وكذلك قواعد الأوراق و ذلك لدراسة إمكانية الاستفادة منها فى إنتاج الإنيولين ، كما اهتمت الدراسة بمعرفة تأثير بعض المعاملات التكنولوجية مثل السلق على ١٠٠°م لأزمنة مختلفة و التخزين تحت تبريد على ٥°م وكذلك التجميد على-٢٢°م ثم التخزين على -١٨°م لمدة أربعة أشهر (بعد إجراء معاملتين هما الغمر فى حامض ستريك ١٪ لمدة ١٠ دقائق و السلق لمدة ٥ دقائق و ذلك بالمقارنة بالعينة الكنترول) على نسبة الإنيولين فى الجزء المأكول من الخرشوف. و لقد أوضحت نتائج الدراسة وجود تأثير معنوى لكل من الحجم و الصنف على نسبة الإنيولين فى الخرشوف ، حيث احتوى الصنف الفرنساوى على نسبة أعلى من الإنيولين مقارنة بالصنف البلدى ، وعموما كان محتوى الإنيولين في الحجم الكبير لكل صنف أعلى مقارنة بالحجم الصغير كما احتوى الجزء القابل للأكل من كل صنف على نسبة أعلى من الإنيولين مقارنة بباقى الأجزاء الأخرى،حيث كانت نسبة الإنيولين ٤١,١١ و٥٢,٥٤٪ فى الجزء القابل للأكل من الحجم الكبير لكل من الصنف البلدى و الفرنساوى على الترتيب . كما تبين من النتائج أن إجراء عملية السلق للخرشوف على ١٠٠°م لأزمنة مختلفة (٥، ١٠، ١٥ دقيقة) قد أدت إلى حدوث خفض معنوى ملحوظ فى نسبة الإنيولين فى الخرشوف حيث زادت نسبة الفاقد من الإنيولين من ٢٥,٧ و ٤٦,٢ و٣١,٨ و٣٣,١٪ إلى ٤٣,٥ و ٤٨,٥ و ٤١,٨ و٤٤,٩ ٪ بزيادة زمن السلق من ٥ إلى ١٥ دقيقة لكل من الحجم الصغير و الكبير لكلا الصنفين البلدى و الفرنساوى على الترتيب. كما أوضحت نتائج الدراسة أيضا قدرة التخزين البارد عند ٥°م على خفض نسبة الفاقد من الإنيولين مقارنة بالعينة الكنترول و المخزنة على درجة حرارة الغرفة حيث احتفظت العينات المبردة بنسبة أكبر من طزاجتها مقارنة بالكنترول و كانت نسبة الفاقد من الإنيولين بعد الأسبوع الثالث من التخزين المبرد هى٤ ٣٢,٦ و ٤٠,٣٨ و٢١,٠٠ و ٤١,١١٪ لكل من الحجم الصغير و الكبير للصنفين على الترتيب بينما فقدت العينة الكنترول طزاجتها و لم تعد صالحة للاستخدام. كما تم أيضا دراسة تأثير عملية التجميد على - ٢٢°م ثم التخزين لمدة ٤ شهور على درجة – ١٨°م على محتوى الإنيولين فى الخرشوف حيث تبين أن غمر الجزء القابل للأكل من الخرشوف فى حامض الستريك بتركيز ١٪ قبيل التجميد قد أدى إلى انخفاض نسبة الفاقد من الإنيولين خلال التخزين مقارنة بالعينة الكنترول و كذلك العينة التى تم معاملتها بالسلق لمدة ٥ دقائق قبيل التجميد .

يتضح من نتائج الدراسة أن الحجم الكبير من الخرشوف يحتوى على نسبة أعلى من الإنيولين مقارنة بالحجم الصغير مع ملاحظة وجود أعلى نسبة من الإنيولين فى الجزء القابل للأكل من نورة الخرشوف ، و أن المعاملة الحرارية قد أدت الى خفض معنوى ملحوظ فى نسبة الإنيولين بينما كان للغمر فى حامض الستريك قبيل التجميد دون إجراء أي معاملة حرارية تأثير ملحوظ فى خفض نسبة الفاقد من الإنيولين خلال عملية التجميد.