# Effect of Some Technological and Chemical Treatments on Keeping Quality of Globe Artichoke (*Cynara scolymus* L.) Heads

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**Abstract:** Globe artichoke (*Cynara scolymus* L.) heads were harvested ,characterized and blanched with water or with different blanching solutions prior to freezing. Effect of lactic or citric acid with or without sodium chloride in blanching solution were studied . Polyphenoloxidase (PPO) activity in blanched artichoke , pH of solution , pH of blanched artichoke , sensory attributes for blanched and frozen artichoke , proximate composition of blanched artichoke , Inulin content of blanched and frozen artichoke , total phenolic content in blanched artichoke and vitamin C were determined . The obtained results, clearly, showed that citric and lactic acid were effective in blanching process . Sodium chloride, also, improved the sensory attributes and reduced the blanching time . The highest inhibition was obtained in solution containing 2% citric acid or lactic with 2% salt (Nacl) for 6 min . These results indicate that citric or lactic acid accelerated the blanching process and reduced time required for complete inactivation of Polyphenoloxidase(PPO) .Texture was improved by decreasing the blanching time,where sensory score increased from 5.1 with blanching solution free of acids and salt to 8.6 with blanching solution contained 2% citric acid with salt . The same trend of results were obtained for colour , taste and odour. Raw globe artichoke contained 72.32 , 19.31 , 1.21 and 7.16 g/100g on dry weight basis for carbohydrate , protein , fat and ash , respectively . The protein content was not affected by blanching with acidified solution while blanching with non acidified solution decreased protein content from 19.31 to 18.43 g/100g. A little decrease was occurred in fat content. Ash content decreased 2.0% in case of blanching solution in non acidified solution ,while decreased 1% in case of acidified blanching solution. Inulin content decreased from 0.380 mg/g to 0.198 mg/g and 0.280 mg/g in blanching with water and blanching with acidified solution,each in turn . Total phenolic decreased from 3.1 $g/kg^{-1}$ in raw sample to 2.70 $g/kg^{-1}$ in blanched sample with water ,while blanching with acidified solution of 1 or 2 % of acids increased the total phenolic to 3.22 and 3.31 $g/kg^{-1}$,respectively . Total phenolic contents were almost stable during storage at -18C up to three months . Blanching with water decreased vitamin C 21% while it was reduced to 12% with acidified blanching solution .**Keywords:**Globe artichoke(*CynaraScolymus* L.), polyphenoloxidase , blanching , total phenolic , freezing ,sensory evaluation .

## Introduction

Globe Artichoke (*Cynara scolymus* L.) is a herbaceous perennial plant native to the Mediterranean Basin. Egypt is ranked the fifth world producer of artichoke with a total production of 74 thousand tons (FAO,2007). Not only globe artichoke is a tasty food in the Mediterranean diet, but also known since ancient time as a folk medicine for its choleretic and diuretic effect .

In recent year, an increasing demand for functional foods with added value has led to a renewed interest in this crop(Lombardo *et al.*,2010).Globe artichoke has a low content of fat and high levels of minerals (potassium, sodium, phosphorus), vitamin C, fibres, polyphenols, flavones, inulin and hydroxycinnamates - caffeoylquinic acid derivatives. (Pandino *et al.*, 2011a, b).The edible part of artichoke heads is characterized by a high reducing sugar content and a high percentage of water-soluble polysaccharides (inulin) as reported by Lattanzio *et al.* (2002).

The daily intake of phenolics in western countries has been estimated to be between 10 and 500 mg (Kanner, 2000). The edible artichoke fraction has

been described as an important source of natural antioxidant with a high phenolic content(618 mg /100 g) as indicated by Gil-Izquierdo *et al.* (2001) . Also, globe Artichoke contains phenolics which are important due to their strong antioxidant properties (Chen and Ho, 1997).

However, recent works begin to indicate the potential role of flavonoids and other phenolics in the prevention of diseases (Gil-Izquierdo *et al.*, 2001). Compared to other vegetables, artichoke is a promising source of antioxidant compounds and contains high levels of total polyphenols in its edible part (Brat *et al.*, 2006).

Liver viral diseases are considered a major health problem in Egypt, frequently causing cirrhosis and liver cancer. Clinical studies showed 70% to 90% of patients with chronic hepatitis, cirrhosis, or hepatocellular carcinoma had HCV infections (Strickland, 2006). The main actions of artichoke's pharmacolgy are: liver and gallbadder bile stimulation, hepatoprotective (liver protector), antihepatotoxic (liver detoxifile) and hypocholestrolemic (lower cholesterol) as reported by Gebbardt ,1997).

The main problem with fresh-cut artichokes is the high browning rate of the cut surfaces (receptacle and bracts) caused by oxidation of phenolics catalysed by polyphenoloxidase (PPO) enzymes, with subsequent formation of dark compounds (Cabezas-Serrano *et al.*, 2009).

Artichokes are a good source of polyphenol oxidases (PPO) that catalyze the oxidation of phenolics to quinones that subsequently induce the formation of secondary products (Esp´ın *et al.*, 1997).

Heat treatment is the most, widely, used method for stabilizing foods because of its capacity to destroy microorganisms and to inactivate enzymes. Blanching is the most common method to inactivate vegetable enzymes ( Marshall *et al.*, 2006).Blanching is an essential step before processing of any vegetable as it destroys the enzymes and microorganisms and helps in prevention of quality deterioration particularly during drying, freezing, frying or storage. Besides, it also expels the air entrapped intercellularly inside the tissues (Lee, 1958).

Blanching and freezing are critical factors which affect and disrupt the cell structure. Over blanching leads to unnecessary colour change and undue tissue softening, while under blanching results in quality deterioration ( Prestamo *et al.*, 1998).

Several chemicals have been used in different plant tissues to prolong postharvest life or to reduce oxidation reaction (Reid, 1986). Those chemical stabilizes colour, texture and quality of processed fruits and vegetable by delaying the onset of oxidation and enzymatic browning (Amiot et al., 1997).Organic acids are, generally, more effective at low pH and high dissociation constants . The most commonly used organic acids in food preservation include: citric, malic, tartaric, benzoic, lactic, and propionic acids (Wu and Kim ,2007).

Like wise ,sodium chloride is a strong oxidizing agent, which can generate chlorine dioxide under acidic conditions.( Lu *et al.*, 2006).Freezing is one of the best methods available in food industry for preserving food products like globe artichoke of high quality. (Fuchigami *et al.*, 1995).

However, high quantity of globe artichoke produced during limited period ( 2 – 3 months) during the year , therefore there is a need to store fresh globe

artichoke with high quality and maintain the content of polyphenolic compound , vitamin C and sensory quality . This work aimed to investigate the effect of some technological and chemical treatments on keeping quality of globe artichoke.

## MATERIALS AND METHODS

Globe artichoke (*Cynara scolymus* L.) (french, cv.) was obtained from farm in Sidi gazy region near kafreEldawar province ,El-Behaira governorate , Egypt. Four hundred and fifty(450) globe artichoke florets were hand-harvested by cutting the stem 5 cm long below the base of the florets for easy packing. Samples were then inspected, visually, to eliminate damaged and poor quality units and to obtain uniformity. After precooling, globe artichokes florets were packed by hand in plastic boxes. Then globe artichokes were transported to the laboratory directly .

### Head parameters

Flower head length , flower Head diameter , flower head weight , Edible part (receptacle) diameter and edible part (receptacle)fresh weight ,were determined in triplicate and the average of determinations were recorded .

### Preparation of Samples

Artichoke florets were processed on the same day at a room temperature ($23\pm 2^{\circ}C$) under good hygienic conditions. florets were hand trimmed using sharp stainless steel knives in order to remove external bracts, leaves and stalks; heads were then washed in tap water . After washing, head trimming was completed by further removing external greener and tougher bracts (inedible fraction) so as to keep just the inner most tender bracts .Artichokes florets heads were, immediately immersed in solutions containing (1% citric acid) for 1 min to prevent browning .After each dipping, the heads were, gently, dried by fan air .Then, they were ready for processing . Artichoke heads were subjected to different blanching treatment as following :

They were added into the boiling water (1:4 w/v) in stainless steel cooker .Antibrowning agent in blanching solution was prepared for each treatment by the addition of the required amount of (citric or lactic acids or salt or combination of acid with salt) . Antibrowning agent was calculated on the base of water volume for each treatment (2.5 litres) to give the required concentration of the blanching solution and one treatment was done without any addition as a control treatment .Artichoke heads were blanched in different solutions containing (citric or lactic acid or salt or combination of acid with salt ). Then the Polyphenoloxidase activity was determined for each time of blanching.

### Determination of Polyphenoloxidase activity

Polyphenoloxidase (PPO) was extracted by Galeazzi *et al.*(1981) methods. Polyphenoloxidase (PPO)activity was determined for raw and blanched globe artichoke as described by Mayer and Harel (1979 ) .

**Proximate chemical composition**

**Moisture content**

Moisture content of fresh globe artichoke heads was determined in air drying oven at 105 ℃ to a constant weight as described in AOAC (1990).

**Crude protein content**

The nitrogen content of dried samples was determined using the micro kjeldahl method and the ammonia was received in 4% boric acid according to the method of AOAC (1990). The crude protein (%) was determined by multiplying the total nitrogen by factor of 6.25.

**Crude fat**

Crude fat content of the dried samples was determined using the petroleum ether (60 – 80 ºC) for 6 hrs in the Soxhlet apparatus as described in the AOAC (1990).

**Ash content**

The ash content of the dried samples was determined according to (AOAC, 1990) .Samples were ashed at 525 - 550 ºC in an electric muffle furnace to constant weight.

**Total carbohydrate content**

The total carbohydrates were estimated by difference (meaning 100 – the sum of moisture, protein, fat and ash).

**pH values**

The pH values of artichokes were determined for raw, blanched artichoke and blanched solutions by using ( Chec-mite USA ) as described by the methods of AOAC (1990).

**Inulin content**

Inulin content was measured by using the method of (Strepkov,1936).

**Total phenolic content ( TPC ) :**

The Folin-Ciocalteu assay was used to quantify the total phenolic content (TPC) as reported by Singleton and Rossi (1965).

**Ascorbic acid :**

Ascorbic acid content of fresh globe artichoke and blanching artichoke was determined according to AOAC (2008) .

**Blanching and storage**

Blanching times were determined for each blanching solutions according to inactivation of polyphenoloxidase (PPO) . After blanching at 90 - 95ºC, Samples were, immediately, cooled in cold water and drained and kept in polyethylene bags at ( -18 ºC) for further analysis and evaluation up to 6 months.

**Sensory evaluations**

Sensorial quality was evaluated by a 10 panalist from staff members of the Food Scince Department of the Faculty of Agriculture (Saba Basha),

Alexandria University to score quality attributes of globe artichoke heads . Samples were scored for overall visual quality by using an interval hedonic scale , where the extremes and center of the Interval were represented as follows : zero ( dislike extremely , no characteristic of the product ) , 5 ( neither like nor dislike , limit of acceptance from the consumer's point of view ) , and 9 ( like extremely , very characteristic of the product ) . The tested attributes such as texture ,colour , odour , taste and overall acceptance were evaluate ,according to (Allende *et al.*, 2007).

## RESULTS AND DISCUSSION

### Head parameters

Results presented in Table (1) show the physical parameters of globe artichoke. Flower head length , flower head diameter , flower head fresh weight , edible part fresh weight and edible part diameter were 10.13 cm , 7.15 g , 330 cm , 57.51 g and 4.39 cm , respectively .

### Effect of blanching on polyphenoloxidase(PPO) activity

Data listed in Table (2) declared that blanching solution containing 1%-2% salt (NaCl) had a little inactivation of PPO and the enzyme was still active up to 14 min of blanching which was near to the activity obtained in control sample being 20.20 , 16.20 and 15.20 % in control sample ,1% and 2% salt, respectively.The texture of globe artichoke heads became too soft and unacceptable after 14 min , according the blanching did not continue after 14 min .Similarly data revealed that complete inhibition of PPO in globe artichoke head blanched with solution containing 1% citric or lactic acid was obtained after 13 min .The time for complete inhibition of PPO was reduced into 12 min by using 1% acids and 1% salt (NaCl), and this time was reduced, also, into 11min in solution containing 1% acids (citric or lactic) combined with 2% salt (NaCl).However , it is clear that increasing concentration of both in acids and salt enhanced inactivation of PPO. The results of this table, also, showed complete inactivation in PPO after 10 min due to using blanching solution containing 2% citric or lactic, and the blanching time was reduced into 8 min due to using 2% citric acid or lactic acid combined with 1% salt (NaCl). The shortest time for inhibition of PPO activity was obtained in solution contained 2% citric acid or lactic with 2% salt (NaCl) for 6 min . It's clear that critic acid and lactic acid have the same effect in PPO inactivation. However PPO play an important role during the shelf-life of artichoke (Lattanzio and Iinsalata, 1989). These results indicate that citric or lactic acid accelerated the blanching process and reduced the time required for complete inactivation of PPO.Citric acid was effective in improving the quality as well as the shelf-life of stored artichoke and delayed the enzymatic browning .Browning may be prevented by inhibiting the activity of PPO by removing one of its necessary reaction components, O2, enzyme, Cu++ contained on its active site, or substrate (Lambrecht, 1995). Chemical methods consist of using different types of additives as reducing, acidulant, chelating, and complexing agents, or compounds that directly inhibit PPO (Garcia and Barrett, 2002).These organic acids have been reported often for their antibrowning activity in fresh-cut fruits and vegetables (Zhu, *et al.*, 2009) and have, generally, recognized as safe (GRAS) status (Pacific Health Sciences, 2008).

**Effect of blanching solution on pH valuses of globe artichoke heads**

Data tabulated in Table (3) represent that pH value dropped from 6.87 in blanching solution without any addition to 2.11 by adding 1% citric acid with 2% salt.In this respect, the pH value of blanched globe artichoke decreased from 6.35 to 4.81 when blanched in solution without addition and blanched in solution with 1% citric acid +2% salt, respectively . Further decreasing in pH value of blanching solution obtained by combined citric or lactic with salt . This result was in favour of blanching efficiency as blanching time was reduced .Increasing acid in blanching solution showed further drop in pH value in both solution and blanched artichoke . Six min was the blanching time obtained by adding 2% citric with 2% salt (Table 2).

Below pH values of ~5, a strongly pH dependent PPO inhibitory effect was observed and the degree of inhibition increases with the acidity of the reaction medium.( Lu *et al.*, 2006).Organic acids are generally more effective at lowering pH and high dissociation constants (Wu and Kim ,2007).

**Effect of blanching on sensory attributes of globe artichoke heads**

Data in Table (4) showed that texture was improved by decreasing the blanching time where , mean sensory score was increased from 5.1 in case of using blanching solution free of acids and salt, to 8.6 using 2% of citric acid and salt in blanching solution as the blanching time reduced from 14 min to 6 min .The same trend of results were obtained for colour , taste and odour . More bright colour was obtained using acid with salt blanching solution . It was evident that acids with salt in blanching solution had improved texture where optimal firmness was obtained using 2% citric or lactic acid ,with salt .Coocking, odour and softeness were clearly observed in blanched artichoke using zero content of acids in blanching solution .Odour had improved in acidified solution and reached the optimum score with 2% acids. Over blanching leads to unnecessary colour changes and tissue softening , while under blanching result in quality deterioration such as off-flavour and off-colour during frozen storage and distribution (Chen *et al* ., 1987) .

**Effect of freezing on sensory attribute of blanched globe artichoke heads**

**Texture**

Data inTable (5)showed that sensory score of texture during storage at -18ºC for 6 months were decreased . Likewise the large drop in texture score of sample treated using water only for 14 min compared with minor decrease in sample blanched in acidified solution after 6 months where the highest score of texture was obtained with the 2% C +2% salt in blanching solution .

**Colour**

The data in Table (6) presented the effect of freezing at -18ºC for six months on the mean sensory score of colour for blanched globe artichoke. It was clear that the maximum decrease in score of colour was observed in globe artichoke blanched in solution free of acids or salt while minimum decrease was

obtained for blanched globe artichoke in acidified solution after storage period at -18ºC.

**Odour**

Table (7) presented the effect of freezing at -18ºC for six months on the mean sensory score of odour for blanched globe artichoke. It was clear that the maximum decrease in score of odour was observed in globe artichoke blanched in solution free of acids or salt while the minimum decrease was obtained for blanched globe artichoke in acidified solution after storage period at -18ºC.

**Taste**

Results in table (8) showed the effect of frozen at -18ºC on sensory score of taste of blanched globe artichoke heads . It was clear that treatment using alow concentration of acids given a high improvement of taste compared with treatment ,using high concentration of acids during the first period of storage. In contrast treatment using high concentration of acid given a high improvement of taste at the end of storage period at -18ºC. Control sample using water only was not determined after 5 months because not acceptable for taste .

**Approximate composition of globe artichoke**

Table (9) presented the approximate composition of raw globe artichoke and blanched globe artichoke in different blanching solution .Raw globe artichoke heads contained 72.32 , 19.31 , 1.20 and 7.16g/100g on dry weight basis for carbohydrate , protein , fat and ash, respectively . Lutz *et al.* (2011) studied the chemical composition and antioxidant properties of mature raw globe artichoke , they found that it contained 75.8 , 15.9 , 1.2 and 7.04% for carbohydrate , protein , fat and ash, respectively ,which were nearly the same as obtained in the present study . It was clear that the protein content was not affected by blanching with acidified solution while blanching with non acidified solution decreased protein content from 19.31 to 18.43g/100g.A little decrease was observed in fat content , for example fat content decrease from 1.21 % to 0.91 % in raw and blanched sample, respectively. Ash content was decreased by about 2.0% in case of blanching solution in non acidified solution while this content decreased to about only 1% in case of using acidified blanching solution.In the same respect, Table (10) showed the effect of freezing on chemical composition of blanched globe artichoke heads after 6 months of storage . The obtained data indicated that freezing for 6 months did not affect carbohydrate content but protein was decreased from 19.22g/100g at zero time to 15.94 g/100g after storage for globe artichoke heads blanched with 1% acid , while for globe artichoke heads blanched with 2% acid protein became 17.33 g/100g . Fat was decreased, also, and the decreasing was reduced by increasing the acid % in blanching solution . The same trend was obtained in case of ash.

**Inulin content**

Izzo (1998) reported that inulin is most widely recognized for its health promoting benefits,where as , Table (11) showed the blanching in water decreased inulin content from 0.380 mg /g to 0.198 mg/g , while this amount of

decrease was reduced to 0.280 mg/g in case of using acidified solution with 2% citric acid+2% salt in the same time . The highest amount of inulin retained in blanched frozen globe artichoke was obtained at blanching with 2% citric acid + 2% salt was 0.245mg/g.

**Total phenolic content**

Globe artichoke head contain phenolics which are important due to their strong antioxidant properties (Chen and Ho, 1997). Compared to other vegetables, glob artichoke is a promising source of antioxidant compounds and contains high levels of total polyphenols in its edible part (Brat *et al.*, 2006).Data in Table (12) show the effect of blanching solution on total phenolic content in blanched frozen globe artichoke during storage at -18ºC for 6 months . It is clear that blanching of water decreased the total phenolic from 3.1 g/kg in raw sample to 2.70 g/kg in blanched sample with water ,while blanching with acidified solution of 1 or 2 % of acids increased the total phenolic to be 3.22 - 3.31 g/kg (Table12) . In the same context ,total phenolic contents were almost stable during storage at -18ºC up to three months , then started to decrease as shown in Table (12) . Cliffored (1999) reported the globe artichoke heads contain up to 450 mg/kg fw Chen and Ho (1997). studied the effect of blanching on total phenolic and they found that total phenolic increased after blanching and they added that the increasing of total phenolic may be partly due to release of bound phenolic and the breakdown or softening of celluiar constituents of plant cell, leaching to augmented accessibility of the antioxidant these complex compounds may be more easily released in relation to those found in the raw plants improving their antioxidant capacity.

**Vitamin C content**

Data in Table (13) declared that the raw sample contained the highest amount (10.93 mg / 100 g) . This amount was in agreement, more or less with Ceccarelli *et al.*,(2010) who reported that globe artichoke heads have a high content of vitamin C (10 mg / 100 g fresh weight ) .Blanching with water decreased vitamin C by 21% while this decreased amount was reduced to 12% with acidified blanching solution . The data, also, showed that higher amount of vitamin C retained after storage for 6 months at -18ºC was obtained in globe artichoke blanched with 2% citric acid in blanching solution.

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**Table(1) Physical parameters of globe artichoke**

| Flower head Length (cm) | Flower head diameter(cm) | Flower head fresh weight (g) | Edible part fresh weight (g) | Edible part diameter (cm) |
|---|---|---|---|---|
| 10.13 * | 330 | 7.15 | 57.51 | 4.39 |

* Values are average of triplicate determination

**Table (2). Effect of Blanching solutions on the Polyphenoloxidase activity in globe artichoke**

| Blanching solution (% w/w) Acid + Salt | Activity of poly phenoloxidase (%) Blanching Time (min ) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 0 + 0 | N.D | N.D | N.D | 71.1 | 70.2 | 63.4 | 51.2 | 43.3 | 39.7 | 34.9 | 28.5 | 20.2 |
| 0 + 1 | N.D | N.D | N.D | 69.4 | 67.5 | 59.5 | 54.4 | 39.9 | 53.3 | 31.2 | 26.4 | 16.9 |
| 0 + 2 | N.D | N.D | N.D | 67.9 | 66.1 | 50.7 | 40.7 | 34.7 | 31.1 | 27.7 | 22.7 | 15.2 |
| 1 [b] + 0 | 44.1 | 43.5 | 40.2 | 39.7 | 37.2 | 33.1 | 28.5 | 21.4 | 14.5 | 7.2 | 0 | |
| 1 [a] + 0 | 43.7 | 42.2 | 40.9 | 40.4 | 36.1 | 31.3 | 26.5 | 15.5 | 10.2 | 4.1 | 0 | |
| 1 [b] + 1 | 43.1 | 41.4 | 40.3 | 32.2 | 28.7 | 21.4 | 15.6 | 8.3 | 6.3 | 0 | | |
| 1 [a] + 1 | 42.4 | 41.1 | 40.8 | 30.5 | 28.1 | 20.9 | 14.6 | 5.1 | 3.7 | 0 | | |
| 1 [b] + 2 | 35.5 | 32.9 | 31.3 | 23.7 | 19.5 | 13.1 | 7.7 | 4.1 | 0 | | | |
| 1 [a] + 2 | 33.1 | 32.3 | 30.5 | 20.2 | 18.4 | 10.3 | 7.0 | 2.7 | 0 | | | |
| 2 [b] + 0 | 15.4 | 18.5 | 16.4 | 16.8 | 14.3 | 9.8 | 8.1 | 0 | | | | |
| 2 [a] + 0 | 13.5 | 11.8 | 11.2 | 13.6 | 12.9 | 9.1 | 5.5 | 0 | | | | |
| 2 [b] + 1 | 8.5 | 8.1 | 7.3 | 11.3 | 9.1 | 0 | | | | | | |
| 2 [a] + 1 | 7.8 | 7.4 | 6.9 | 8.8 | 8.3 | 0 | | | | | | |
| 2 [b] + 2 | 6.1 | 5.5 | 3.7 | 0 | | | | | | | | |
| 2 [a] + 2 | 5.7 | 5.1 | 2.8 | 0 | | | | | | | | |

*ND (not determinated because of quickly blacking occurred ) .
Salt = sodium chloride .
a = citric acid .
b = [illegible]ic acid.

**Table (3). Effect of acids and salt on pH value of blanching solution and blanched artichoke .**

| Blanching solution (w/w %) Acid + Salt | Blanching time (min) | pH value of blanching solution | pH value of blanched artichoke |
|---|---|---|---|
| 0 + 0 | 14* | 6.87 | 6.35 |
| 1[a] + 2 | 11 | 2.11 | 4.81 |
| 1[b] + 2 | 11 | 2.15 | 4.83 |
| 2[a] + 0 | 10 | 2.89 | 4.60 |
| 2[b] + 0 | 10 | 2.95 | 4.65 |
| 2[a] + 1 | 8 | 2.21 | 4.10 |
| 2[b] + 1 | 8 | 2.33 | 4.21 |
| 2[a] + 2 | 6 | 1.87 | 3.85 |
| 2[b] + 2 | 6 | 1.91 | 3.99 |

pH value of raw sample = 6.23
a = Citric acid.
b = Lactic acid.
* Blanching was stoped after 14 min because texture was unacceptable.

**Table (4 ). Effect of acidified blanching solutions on sensory score values of blanched globe artichoke**

| Blanching solution acid + Salt w/w %)( | Blanching time | Mean sensory score | | | |
|---|---|---|---|---|---|
| | | Texture | Color | odour | Taste |
| --- + --- | --- | 8.98* | 2.1* | 8.20* | 7.80* |
| 0 + 0 | 14 | 5.10 | 6.65 | 7.10 | 7.10 |
| 1[a] + 2 | 11 | 7.22 | 7.85 | 7.50 | 8.21 |
| 1b + 2 | 11 | 7.15 | 7.73 | 7.22 | 8.15 |
| 2[a] + 0 | 10 | 7.63 | 8.25 | 7.53 | 7.25 |
| 2b + 0 | 10 | 7.55 | 8.00 | 7.41 | 6.50 |
| 2[a] + 1 | 8 | 8.21 | 8.56 | 8.15 | 7.91 |
| 2b + 1 | 8 | 7.87 | 8.20 | 7.51 | 7.10 |
| 2[a] + 2 | 6 | 8.60 | 8.93 | 8.45 | 7.97 |
| 2b + 2 | 6 | 8.00 | 8.51 | 7.80 | 7.45 |

* Raw globe artichoke .
a = Citric acid.
b = Lactic acid.

**Table (5). Effect of freezing on some of chosen blanched globe artichoke on sensory score values of texture during storage.**

| Blanching solution acid + Salt (w/w%) | Blanching time (min) | Mean sensory score of texture Storage period (months) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 + 0 | 14 | 5.10 | 5.00 | 4.87 | 4.30 | 4.00 | 3.20 | 2.00 |
| 1[a] + 2 | 11 | 7.22 | 7.12 | 7.00 | 6.69 | 6.49 | 6.32 | 6.18 |
| 1[b] + 2 | 11 | 7.15 | 7.03 | 7.00 | 6.65 | 6.43 | 6.25 | 6.05 |
| 2[a] + 0 | 10 | 7.63 | 7.44 | 7.22 | 6.92 | 6.67 | 6.47 | 6.32 |
| 2[b] + 0 | 10 | 7.55 | 7.33 | 7.08 | 6.77 | 6.52 | 6.29 | 6.13 |
| 2[a] + 1 | 8 | 8.21 | 8.06 | 7.90 | 7.71 | 7.56 | 7.45 | 7.35 |
| 2[b] + 1 | 8 | 7.87 | 7.69 | 7.49 | 7.23 | 7.01 | 6.83 | 6.70 |
| 2[a] + 2 | 6 | 8.60 | 8.49 | 8.35 | 8.19 | 8.06 | 7.96 | 7.88 |
| 2[b] + 2 | 6 | 8.00 | 7.84 | 7.67 | 7.44 | 7.24 | 7.06 | 6.94 |

a = Citric acid.
b = Lactic acid.

**Table (6.) Effect of freezing on some of chosen blanched globe artichoke on sensory score values of colour during storage.**

| Blanching solution acid + Salt (w/w%) | Blanching time (min) | Mean sensory score of colour Storage period (months) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 + 0 | 14 | 6.65 | 4.73 | 4.59 | 4.50 | 4.00 | 3.10 | 2.00 |
| 1[a] + 2 | 11 | 7.85 | 7.74 | 7.66 | 7.37 | 7.12 | 6.67 | 6.70 |
| 1[b] + 2 | 11 | 7.73 | 7.59 | 7.49 | 7.17 | 6.89 | 7.67 | 6.47 |
| 2[a] + 0 | 10 | 8.25 | 8.16 | 8.10 | 7.84 | 7.62 | 7.47 | 7.36 |
| 2[b] + 0 | 10 | 8.00 | 7.91 | 7.83 | 7.55 | 7.33 | 7.17 | 7.05 |
| 2[a] + 1 | 8 | 8.56 | 8.49 | 8.55 | 8.31 | 8.11 | 7.98 | 7.88 |
| 2[b] + 1 | 8 | 8.20 | 8.12 | 8.04 | 7.79 | 7.58 | 7.43 | 7.33 |
| 2[a] + 2 | 6 | 8.93 | 8.90 | 8.85 | 8.65 | 8.48 | 8.38 | 8.28 |
| 2[b] + 2 | 6 | 8.51 | 8.45 | 8.39 | 8.18 | 7.98 | 7.85 | 7.74 |

a = Citric acid.
b = Lactic acid

**Table (7). Effect of freezing on some of chosen blanched globe artichoke on sensory score values of odour during storage.**

| Blanching solution acid + Salt (w/w%) | Blanching time (min) | Mean sensory score of odour | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Storage period (months) | | | | | | |
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 + 0 | 14 | 7.10 | 5.00 | 5.88 | 5.63 | 5.30 | 5.00 | 3.70 |
| 1[a] + 2 | 11 | 7.50 | 7.50 | 7.30 | 7.00 | 7.00 | 7.00 | 6.50 |
| 1[b] + 2 | 11 | 7.22 | 7.20 | 7.00 | 7.00 | 6.8 | 6.5 | 6.30 |
| 2[a] + 0 | 10 | 7.53 | 7.50 | 7.50 | 7.20 | 7.00 | 7.00 | 7.00 |
| 2[b] + 0 | 10 | 7.41 | 7.40 | 7.40 | 7.00 | 7.00 | 7.00 | 6.70 |
| 2[a] + 1 | 8 | 8.15 | 8.00 | 7.80 | 7.70 | 7.60 | 7.50 | 7.40 |
| 2[b] + 1 | 8 | 7.51 | 7.50 | 7.50 | 7.5 | 7.3 | 7.10 | 7.10 |
| 2[a] + 2 | 6 | 8.45 | 8.35 | 8.20 | 8.00 | 7.93 | 7.83 | 7.76 |
| 2[b] + 2 | 6 | 7.80 | 7.80 | 7.80 | 7.60 | 7.50 | 7.50 | 7.30 |

a = Citric acid.
b = Lactic acid.

**Table (8). Effect of freezing on some of chosen blanched globe artichoke on sensory score values of taste during storage.**

| Blanching solution acid + Salt (w/w%) | Blanching time (min) | Mean sensory score of taste | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Storage period (months) | | | | | | |
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 + 0 | 14 | 7.10 | 6.50 | 5.85 | 5.00 | 4.10 | --- | --- |
| 1[a] + 2 | 11 | 8.21 | 8.20 | 8.20 | 8.30 | 8.30 | 8.50 | 8.50 |
| 1[b] + 2 | 11 | 8.15 | 8.00 | 8.00 | 8.00 | 8.20 | 8.20 | 8.40 |
| 2[a] + 0 | 10 | 7.25 | 7.00 | 7.00 | 7.20 | 7.20 | 7.50 | 7.50 |
| 2[b] + 0 | 10 | 6.50 | 6.50 | 6.50 | 6.70 | 6.70 | 6.70 | 7.10 |
| 2[a] + 1 | 8 | 7.91 | 7.60 | 7.60 | 7.80 | 7.80 | 8.00 | 8.00 |
| 2[b] + 1 | 8 | 7.10 | 7.10 | 7.20 | 7.20 | 7.50 | 7.50 | 7.50 |
| 2[a] + 2 | 6 | 7.97 | 7.80 | 7.80 | 7.90 | 8.00 | 8.20 | 8.30 |
| 2[b] + 2 | 6 | 7.51 | 7.5 | 7.5 | 7.5 | 7.7 | 7.90 | 7.90 |

a = Citric acid.
b = Lactic acid.

**Table (9). Effect of blanching solution on proximate composition of globe artichoke (on dry weight basis ).**

| Blanching solution acid + Sal (w/w%) | Blanching time(min) | Moisture (%) | Carbohydrate (g/100g) | Protein (g/100g) | Fat (g/100g) | Ash (g/100g) |
|---|---|---|---|---|---|---|
| --- + --- | --- | 79.93* | 72.32* | 19.31* | 1.21* | 7.16* |
| 0 + 0 | 14 | 83.73 | 74.78 | 18.43 | 0.87 | 5.92 |
| 1[a] + 2 | 11 | 82.95 | 73.80 | 19.22 | 0.91 | 6.07 |
| 1[b] + 2 | 11 | 83.11 | 73.91 | 19.17 | 0.89 | 6.03 |
| 2[a] + 0 | 10 | 82.72 | 73.04 | 19.83 | 0.94 | 6.19 |
| 2[b] + 0 | 10 | 82.98 | 73.21 | 19.68 | 0.94 | 6.17 |
| 2[a] + 1 | 8 | 82.47 | 72.34 | 20.21 | 1.07 | 6.38 |
| 2[b] + 1 | 8 | 82.61 | 72.79 | 20.01 | 0.99 | 6.21 |
| 2[a] + 2 | 6 | 82.03 | 72.93 | 20.53 | 1.12 | 6.42 |
| 2[b] + 2 | 6 | 82.97 | 72.01 | 20.41 | 1.09 | 6.40 |

* Raw globe artichoke .
a = Citric acid.
b = Lactic acid .

**Table (10). Effect of freezing on proximate composition of blanched globe artichoke after 6 months of storage (on dry weight basis ) .**

| Blanching solution acid + Salt (w/w%) | Blanching time(min) | Moisture (%) | Carbohydrate (g/100g) | Protein (g/100g) | Fat (g/100g) | Ash (g/100g) |
|---|---|---|---|---|---|---|
| --- + --- | --- | 79.93* | 72.32* | 19.31* | 1.21* | 7.16* |
| 0 + 0 | 14 | ND** | ND** | ND** | ND** | ND** |
| 1[a] + 2 | 11 | 85.89 | 77.54 | 15.94 | 0.70 | 5.82 |
| 1[b] + 2 | 11 | 85.93 | 77.92 | 15.63 | 0.67 | 5.78 |
| 2[a] + 0 | 10 | 85.61 | 76.71 | 16.59 | 0.76 | 5.94 |
| 2[b] + 0 | 10 | 85.69 | 77.13 | 16.20 | 0.75 | 5.92 |
| 2[a] + 1 | 8 | 85.22 | 75.99 | 16.98 | 0.87 | 6.16 |
| 2[b] + 1 | 8 | 85.20 | 76.68 | 16.56 | 0.79 | 5.97 |
| 2[a] + 2 | 6 | 84.55 | 75.51 | 17.33 | 0.93 | 6.23 |
| 2[b] + 2 | 6 | 84.68 | 75.92 | 16.99 | 0.89 | 6.20 |

* Raw globe artichoke .
**ND (not determinated because of unacceptable for appearance and texture).
a = Citric acid.
b = Lactic acid .

**Table (11). Effect of Blanching solutions on Inulin content in blanched frozen globe artichoke after storage at –18ºC for 6 months (mg/g dry weigh) .**

| Blanching solution acid + Salt (w/w%) | Blanching time (min) | Time of storage | |
|---|---|---|---|
| | | Zero time | After 6 months |
| 0 + 0 | 14 | 0.198 | ND* |
| 1[a] + 2 | 11 | 0.205 | 0.110 |
| 1[b] + 2 | 11 | 0.200 | 0.100 |
| 2[a] + 0 | 10 | 0.220 | 0.150 |
| 2[b] + 0 | 10 | 0.205 | 0.115 |
| 2[a] + 1 | 8 | 0.240 | 0.180 |
| 2[b] + 1 | 8 | 0.218 | 0.150 |
| 2[a] + 2 | 6 | 0.280 | 0.245 |
| 2[b] + 2 | 6 | 0.250 | 0.208 |

Inulin of raw sample = ( 0.380 mg/g dry weigh).
*ND (not determinated because not acceptable).
a = Citric acid.
b = Lactic acid .

**Table(12). Effect of Blanching solution on total phenolic content in blanched frozen globe artichoke during storage at –18ºC for 6 months .**

| Blanching solution Acid + Salt (w/w%) | Blanching time (min) | Total Phenolic content during storage(g/kg$^{-1}$) . Storage period (months) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 + 0 | 14 | 2.70 | 2.51 | 2.23 | 1.80 | 1.27 | ND* | ND* |
| 1[a] + 2 | 11 | 3.22 | 3.24 | 3.29 | 3.33 | 3.00 | 2.74 | 2.62 |
| 1[b] + 2 | 11 | 3.18 | 3.19 | 3.25 | 3.30 | 3.00 | 2.73 | 2.59 |
| 2[a] + 0 | 10 | 3.25 | 3.25 | 3.30 | 3.39 | 3.08 | 2.84 | 2.74 |
| 2[b] + 0 | 10 | 3.23 | 3.24 | 3.26 | 3.35 | 3.03 | 2.78 | 2.68 |
| 2[a] + 1 | 8 | 3.26 | 3.26 | 3.32 | 3.45 | 3.17 | 2.95 | 2.88 |
| 2[b] + 1 | 8 | 3.25 | 3.25 | 3.30 | 3.40 | 3.11 | 2.89 | 2.80 |
| 2[a] + 2 | 6 | 3.31 | 3.32 | 3.37 | 3.52 | 3.27 | 3.09 | 3.06 |
| 2[b] + 2 | 6 | 3.29 | 3.31 | 3.33 | 3.45 | 3.17 | 2.97 | 2.92 |

Total Phenolic of raw sample = ( 3.1 g/ kg–1 FW) .
*ND (not determinated because of unacceptable for appearance and texture).
a = Citric acid.
b = Lactic acid.

**Table (13). Effect of Blanching solutions on vitamin C content in blanched frozen globe artichoke during storage at – 18C for 6 months .**

| Blanching solution Acid + Salt (w/w%) | Blanching time (min) | Vitamin C content during storage (mg/100g) Storage period (months) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 + 0 | 14 | 8.63 | 8.47 | 6.26 | 5.16 | 4.17 | ND | ND |
| 1[a] + 2 | 11 | 9.13 | 8.99 | 8.81 | 8.73 | 7.77 | 6.77 | 6.67 |
| 1[b] + 2 | 11 | 9.09 | 8.93 | 8.72 | 8.64 | 7.64 | 6.64 | 6.54 |
| 2[a] + 0 | 10 | 9.27 | 9.16 | 8.99 | 8.92 | 8.83 | 8.76 | 8.69 |
| 2[b] + 0 | 10 | 9.18 | 9.06 | 8.89 | 8.82 | 8.72 | 8.63 | 8.55 |
| 2[a] + 1 | 8 | 9.40 | 9.32 | 9.18 | 9.13 | 8.58 | 8.51 | 8.44 |
| 2[b] + 1 | 8 | 9.35 | 8.31 | 8.16 | 8.10 | 8.05 | 7.98 | 7.90 |
| 2[a] + 2 | 6 | 9.59 | 9.51 | 8.41 | 9.38 | 9.35 | 9.31 | 9.28 |
| 2[b] + 2 | 6 | 9.53 | 9.45 | 9.31 | 9.26 | 9.21 | 9.16 | 9.11 |

Vitamin C of raw sample = ( 10.93mg/100g FW ) .
*ND (not determinated because of unacceptable for appearance and texture ).
a = Citric acid.
b = Lactic acid.

## الملخص العربي

# تاثير بعض المعاملات التكنولوجية والكيماوية على حفظ جودة الخرشوف المجمد

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تم إجراء بعض معاملات مابعد الحصادعلى نورات الخرشوف وإعداده للسلق بواسطة محاليل سلق تختلف في محتواها من الأحماض وملح الطعام وذلك قبل التجميد. كما تمت دراسة نشاط إنزيم البولي فينول أوكسيديز (PPO) وقيمة الpH لكل من محلول السلق والخرشوف الذي تم سلقه و كذلك الخواص الحسية لنورات الخرشوف الذي تم سلقه والمجمد والتركيب الكيميائي للخرشوف ومحتواه من الأنيولين بالإضافة إلى محتواه من المواد الفينولية وفيتامين C. أظهرت النتائج المتحصل عليها فاعلية حمض الستريك واللاكتيك في السلق ، كذلك تبين أن إستخدام الملح مع الأحماض يؤدي إلى خفض قيمة ال pH لمحاليل السلق وزيادة تثبيط إنزيم (PPO) ، كما أن الملح يحسن من الخواص الحسية ويخفض من زمن السلق .أوضحت الدراسة أن أعلى تثبيط لنشاط إنزيم(PPO) تم في محلول السلق المحتوي على 2% من حمض ستريك أو حمض اللاكتيك مع 2% ملح ، حيث إستغرق تمام السلق 6 دقائق فقط ، كذلك أظهرت النتائج أيضاً أن حمض الستريك أو حمض اللاكتيك قد حفزا عملية السلق مما أدى الى خفض الزمن المطلوب لإتمام تثبيط إنزيم (PPO) .أوضحت النتائج أيضاً أن القوام تحسن بخفض زمن السلق حيث ظهر من التقييم الحسي إرتفاع درجة جودة القوام من 5,1 عند السلق في الماء بدون إي إضافات إلى 8,6 باستخدام محلول السلق المحتوي على2% ستريك +2% ملح، و إرتفعت أيضاً درجة تقييم اللون وطعم ورائحة الخرشوف . أظهرت النتائج أيضاً أن الخرشوف يحتوي على 72,32 ، 19,31 ، 1,21 ، 7,16 جم/100جم من الكربوهيدرات والبروتين والدهن والرماد، على التوالي . كذلك لم يتاثر البروتين بواسطة السلق في المحاليل المحتوية على الأحماض ، بينما في المحاليل غير المحتوية على أي إضافات، لقد لوحظ إنخفاض في محتوى البروتين من 19,31 جم/100جم الى 18,43 جم /100جم . كما أظهرت النتائج إنخفاضاً بسيطاً في محتوى الدهن. كذلك إتضح أن الرماد قد إنخفض بنسبة 2% في محلول السلق غير المحتوي على أحماض بينما إنخفض بنسبة 1% في محاليل السلق المحتوية على تلك الأحماض . وأوضحت النتائج أيضاً أن محتوى الأنيولين قد إنخفض من 0,380 مجم/جم إلى 0,198 مجم/جم و 0,280 مجم/جم في كل من الخرشوف المسلوق في الماء والمسلوق في محاليل الأحماض، على التوالي . كما حدث إنخفاض في المواد الفينولية من 3,1جم/كجم في الخرشوف الخام الى 2,7 جم/كجم في الخرشوف الذي تم سلقه في الماء فقط في حين أن السلق باستخدام محاليل الأحماض بتركيز 1 أو 2 % قد إزداد فيها محتوى المواد الفينولية إلى 3,22 جم/كجم و 3,31 جم/كجم على التوالي ، كما أن محتوى المواد الفينولية ظل ثابتاً خلال التجميد على -18م لمدة ثلاثة شهور ، كماأظهرت النتائج أن السلق في الماء فقط أدى إلى إنخفاض في محتوى فيتامين C بنسبة 21% بينما كانت قيمة الإنخفاض 12% فقط في محاليل السلق المحتوية على الحامض .