International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.7, No.6, pp 2565-2572, 2014-2015

# Effect of Preliminarily Treatments on Quality Parameters of Artichoke with Different Preservation Methods

**L. Abdulaziz, S. Yaziji, and A. Azizieh**

**Food Science Department - Faculty of Agriculture - Damascus University- Syria**

**Abstract:** This research aimed at investigating the effect of preliminary treatments of fresh Artichoke (blanching period, salting, adding acid), on quality parameters of canned and frozen Artichoke before and over a six months period of preserving. In addition, the research tested the efficiency of the applied blanching process was by exploring the presence of enzymes that causes Enzymatic browning. The results showed the freezing method was more preserving to Artichoke's parameters, in comparison with the canned artichoke. Preserving Artichoke for six months resulted in significant reduction of its biochemical content. Blanching resulted in eliminating the enzymes caused Artichoke's coloring and browning. Furthermore, the results revealed that blanching period of 10-20 minutes had contributed to increasing the level of effective biological components. Adding Acid (2%) and the Calcium chloride salt (1-2%) resulted in significant increase in quality parameters for canned and frozen artichoke, compared to the control (which just preserved without any applied processes).

**Key words:** Artichoke, Freezing, Canning, Quality Parameters, Blanching efficient.

## Introduction:

The artichoke (Cynara scolymus L.), is a perennial thistle originating in Mediterranean region and parts of Europe, known in Syria since ancient times[1], 60% of the world production of artichoke came from Mediterranean region[2], and an estimated cultivated area of 200 hectares in Syria distributed around the major cities [3]. Artichokes is as a rich vegetables in nutritional value, so it recommended for diabetics because of its high fiber content and the presence of inulin compound which decomposes to fructose, and is used as a medicine for the treatment of the liver and gall bladder diseases and lower blood cholesterol[4, 5] , recent studies indicate a high content of antioxidants (phenols), where it ranked Artichoke as a fourth of the top ten foods that provide the largest proportion of antioxidants in the ration per nutritional[6] , The edible portion of the buds consists primarily of the fleshy lower portions of the involucral bracts and the base, known as the "heart"; the mass of immature florets in the center of the bud is called the "choke" or beard, These contain a large group of oxidizing enzymes like Peroxidase and Catalase that work on the oxidation of some phenolic compounds and cause the black color during Artichokes processing[7].

So there is a need to find a better way to save artichoke qualities and reduce the exposure of vegetables to the lowest possible manufacturing treatment[8], especially, that Syria provides appropriate environmental conditions for artichoke and as it is a seasonal plant, there is a need to make artichoke available around the year to be manufactured and exported to neighboring countries. Therefore, we resort to freezing and canning as treatment methods to maintain preserve of the nutritional properties and reduce the exposure to more manufacturing transactions and food additives[9]. In order to freeze and can Artichokes, while preserving its qualities, there are a lot of steps to follow, like adding some components and brines such as citric acid, which is used to reduce the pH and prevent changes in the color of the product, and calcium chloride salt to maintain appropriate hardness of vegetables during thermal treatment[10].

## Materials and methods:

1) **Samples preparation:** /294/ samples were collected from different sources of local markets, and were peeled from the internal papers and the hairs to get the edible heads which flooded with a solution of water and citric acid in order to maintain the color of the heads, heads were washed well with cold water and then subjected to the process of blanching.

2) **Blanching process:** The samples (except the control ones) added to /16/ preheated water solutions that had different concentrations of Calcium chloride salt ($CaCl_2$) and Citric Acid (Table 1).These mixtures (samples with solutions) were heated for three time periods (10 -20 -30) minutes. /48/ indentified treatments were applied on the samples and numbers were given from (1 to 48) to these treatments (Table 2).

**Table (1):The different concentrations of salt and acid that added to water solution.**

| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | **Water solution** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 4 | 2 | 0 | 6 | 4 | 2 | 0 | 6 | 4 | 2 | 0 | 6 | 4 | 2 | 0 | **Citric Acid%** |
| 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | **Calcium Chloride salt%** |

**Table (2):/48/ applied treatments on the samples during Blanching process.**

| **Treatments** | **Blanching solutions** | | | | | | | | | | | | | | | | **Blanching periods** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
| | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 10 min |
| | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 20 min |
| | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 30 min |

3) **Freezing and Frozen Storage:** 50% of the samples were immediately cooled after the blanching process and mobilized into polyethylene bags leaving little gaps in those bags before sealing them to protect from freezing damage, after that these samples were stored for /6/ months at /-18/c ̊.

4) **Canning and Canned Storage:** 50% of samples were mobilized into glass jars with their boiling solutions and sterilized at /121/ c̊ for /13/ minutes, and at the end of the sterilization, samples were kept in a cool and dark place for /6/ months [11].

5) **Chemical analysis:** the chemical content of Artichoke (protein – fat –humidity –ash) estimated according to AOAC (2006)[12] while carbohydrates rations were estimated after subtracting the previous ingredients ratios of 100.

6) **Antioxidant activity and Total content of Phenols and Vitamin C:** Total Phenols Content were extracted [13], and the Phenols estimated quantified according to Folin-Ciocalteu method[14].Antioxidant activity estimated by 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical [15]. Also Vitamin C was estimated according to the calibration dye 6.2 dual chlorophenyl indophenol method[16].

7) **Detection of catalase and peroxidase activity to ensure the efficiency of the boiling process:** the detection of catalase activity applied by using solution of hydrogen peroxide (H2O2), and for peroxidase enzyme Dorfner method was used[17].

8) **Statistical analysis:** Experimental data were analyzed using experiment on complete random segments, by repeating each transaction, then conducted analysis of variance using the General linear model test(5%), and F Test and variance distributes to determine the relative importance of the effect of the studied variables on the samples, all these tests were evaluated by using MINITAP program version 14.

## Results and Discussion:

### I. Chemical analysis results:

Humidity content of all /294/ samples (with control) have been studied and the results showed that calcium chloride salt factor was responsible for humidity decrease by about 56.2% ($p < 0.05$) (Fig 1), with humidity values ranged between 78% and 92. 5%, and indicated that Blanching can result in undesirable softening of vegetable tissues. However, calcium can be added to reduce the softening and keep the strength of the artichoke, and with higher concentration of Calcium, the ability of the product to acquire part of the boiling water is reduced[18]. While it was observed that during blanching period the moisture content had increased (8.24%) when the blanching period time had been increased, and this was as a result of partly absorption of blanching water [19, 20] .(Fig 1), As for the preservation methods, there was no significant differences for treatment samples, but there was significant differences between the zero moment and after six months of storage for treatment samples [21], The preservation methods and the time of the blanching had an effect on ashes, the percentages of calcium (especially 3% $CaCl_2$) increased retention in ash samples by 24%, where calcium ions contributed to the increasing severity of the structural composition of plant tissue of the artichoke. Calcium also increased the resistance of this fabric of the laceration and degradation by applied heat during the blanching [22]. While increasing blanching period had a negative effect on ash content 20%, that was due to salts movement to the boiling solution, causing loss in ash content [20], and there were significant differences between the three blanching periods. Canning and Canned storage had good effect in maintaining the ash content compared with the frozen treatment samples, explains that the canning process helps to keep the components and salts of samples as a result of iso-osmotic balance that had happened between Artichokes and brine [23]. Regarding to freezing and frozen storage, the formation of ice crystals in the distances between cells causes later rupture cells and displaces components and salts to outside (hemorrhages frozen materials incident during thawing [24], there was no significant effect of acid on ash.

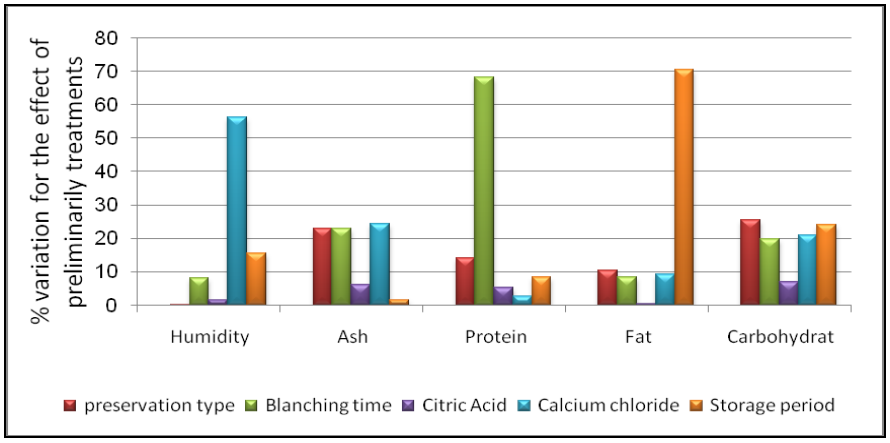


**Figure 1: Effect of the preliminary treatments on the chemical composition of Artichokes.**

All applicable treatments affected significantly ($p < 0.05$) on the protein content in the studied samples, its values ranged between ( 0.3% to 3%), the major effect resulted of boiling time that decreased protein by (68.17%), and it is consistent with several studies which showed that the protein content is reduced with the application of heat treatment for many of the vegetables[20] , While it was inconsistent with the study conducted on the cooked and fresh Artichoke[25] and it explains that the structural composition of vegetable plays a role in restricting or edit chemical components within it, according to the applied thermal treatment, and the longer blanching period which exposed proteins to more heat. There were significant differences between the Preservation methods for each of the control and treatment samples ($p < 0.05$), which indicates the impact of storage temperature on proteins, and observed a significant difference between zero added salt and 3% salt ($p < 0.05$), where increased to maintain the ratio of protein (Fig 1) as explained previously by increasing the hardness of Artichoke[22], while increasing acid concentration affected negatively in terms of reducing the protein content [26]. There was a significant effect of the storage period factor ($p < 0.05$) on treatment samples, which can be resulted from protein decomposition during the storage period [27, 28]. Also, the storage period factor had a major role in increasing the fat content of treatment samples (despite the low fat content of the artichoke) by (70.45%), due to the activity of enzymes oxidizing fat during the long storage period[29]. Clearly, there was a significant impact for preservation methods ($p < 0.05$) on the lipid content of the samples, where the proportion of fat in canned samples rose to 2.5% compared with 1.8% for frozen samples, we can explain that by canned

material stored at room temperature which was helped by oxidation stimulating for fat[30]. The effect of each of the studied factors had varied on carbohydrate ratio, which ranged between 5% to 18.87%, and the greatest impact was for preservation method by (25.42%) ($p < 0.05$), the carbohydrate ratio increased by each of the preservation period, the blanching time and percentage of Calcium salt, while decreased with increased percentage of acid (Fig 1), which the contribution of thermal treatment on strength of sample and made it softer for edit carbohydrates, Conversely the acidity which has modified the chemical structure of the carbohydrate into simpler compounds [31,32].

**2. Biologically Active substances analysis:**

**a. Total Content of Phenols (TCP):** the content of total phenols was measured and ranged between 127.6 mg / 100 g (dry matter) of fresh sample, 69-189 mg / 100 g (dry matter) of the samples that boiled before storage, 111.3 mg / 100 g (dry matter) of frozen artichoke stored for 6 months and up to 138.5 mg / 100 g (dry matter) of canned artichoke stored for 6 months. In Fig (2) shown The impact of storage period factor on the total phenols compared with the rest of the other factors who had significant effect ($p < 0.05$) by 73.55% on the treatment samples and 49% on control, where increase in storage period led to a decline in the total content of phenols[33], also blanched for 30 min had a bad effect on TCP, Instead of that the blanching for (10-20) min had a positive role in increasing TCP and enhanced its antioxidant power, these two periods(10-20) min soften the plant tissues and made these complex Components more likely to be free because of the thermal treatment which broken down the phenolic acids links that became more able to do its role and measure by Fulin detector, comparing with fresh plant [34] (Fig 2). It was observed that the concentration (2- 4%) of citric acid and concentration (1-3 %) of calcium chloride salt were better to maintain the phenols. As for the method of conservation, there was a significant difference ($p < 0.05$) between the canning and freezing, and canned artichoke was the best.

**b. Ascorbic Acid (vitamin C):** the most effect on losing vitamin C in treatment samples was the storage period factor ($p < 0.05$), due to Ascorbate oxidase enzyme activity which enhanced during the storage period [35,36], also there is another factor that had a bad effect in reducing vitamin C content, it was the blanching time which reached its impact about 22% of the loss in the content of vitamin C [37]. As for the way of conservation, through results the freezing was the best ways to preserve the vitamin C [38] (Fig 2), there was no significant effect of salt and acid factors on the content ascorbic acid in samples.

**c. Estimate the antioxidant activity by 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical:** the antioxidant activity values ranged between 59% for fresh sample, 20 to 89% in boiled samples and between 20 to 45% of the samples that stored for 6 months. From the results we Found the antioxidant activity had been increased when the samples blanched for (10.20) minutes, even though there was some sensitive antioxidants to high temperature were damaged (vitamin C) [39, 19] . In other side the storage and preservation factors had a bad significant effect in antioxidant activity, which reaching influence to 76.65% reduction in antioxidant activity [33], due to the impact of conservation period on the total content of phenols, as well as vitamin C, which reflected negatively on the ability of anti-oxidant. It was observed that concentration (2-4%) of citric acid and concentration (1- 3%) of calcium chloride salt was the best concentrations in maintaining the antioxidant activity. Comparing between frozen and canned Artichoke, the frozen one was better than canned one because the loss in antioxidants be higher in canned artichokes compared with frozen [40] (Fig 2).

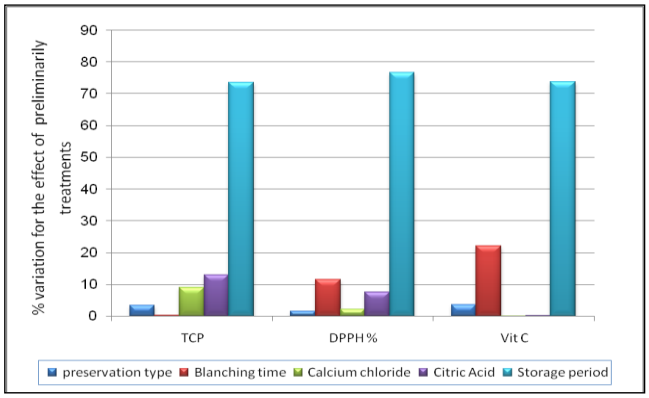


**Figure 2: Effect of the preliminary treatments on the biologically active substances in Artichokes.**

In this research a strong correlation was found between phenols and total activity antioxidant (r2 = 0.93 - 0.77) for the control and treatment samples respectively, while it reached correlation between vitamin C and activity antioxidant to (r2 = 0.55 – 0.32) and we noted the correlation between vitamin C and activity antioxidant for control was lower than the correlation for the samples, because the blanching and the other factors in general led to enhance the antioxidant value in the Artichoke [41, 42] (Fig 3, Fig 4).

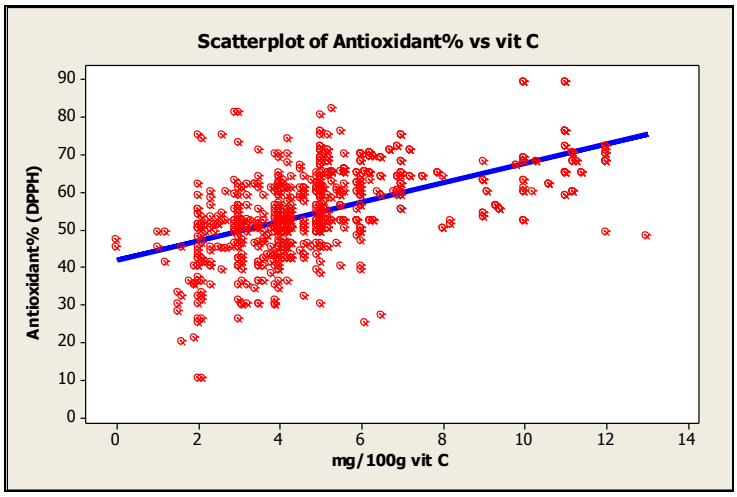


**Figure 3: Correlation between the vitamin C and the antioxidant activity which measured by DPPH.**

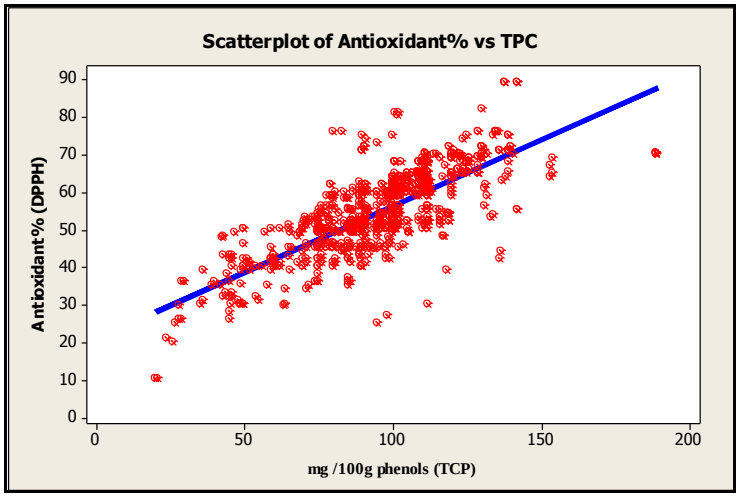


**Figure 4: Correlation between the Total Content of Phenols and the antioxidant activity which measured by DPPH.**

### 3. Detect the presence of Peroxidase and Catalase enzymes to ensure the efficiency of the process of blanching:

After looking for any activity of Peroxidase and Catalase enzymes in both control and blanched samples, found an activity for both enzymes in Control and Sample which blanched for /10/ min, but there wasn't any trace for these enzymes in sampled which blanched for /20-30/ min and this result consistent with a study conducted by Abdullah [21] on the artichokes where boiled for three periods (Table 3).

**Table (3): The effect of blanching process on the activity for Catalase and Peroxidase enzymes (the Blanching efficient).**

| Treatment | The Catalase enzyme | notes | The Peroxidase enzyme | notes |
|---|---|---|---|---|
| **Control** | + | There were a lot of bubbles on the surface. | + | Brown pigment |
| **Blanching for 10 min** | + | There were some of bubbles on the | + | Red pigment |

| | | surface. | | |
|---|---|---|---|---|
| **Blanching for 20 min** | - | Clear surface | - | No reaction |
| **Blanching for 30 min** | - | Clear surface | - | No reaction |

**Conclusions and recommendations:**

## I. Conclusions:

1. Blanching process kept on the natural color of Artichoke, and delayed all enzymatic browning which causes changes in the color by inhibition of enzymes that cause (Catalase and Peroxidase), and the best time for getting the perfect qualities for chemical and nutrition properties is /20/ min.
2. Storage period for both preservation methods had a negative influence on Artichoke's characteristics, especially the chemical composition.
3. There was a significant effect on vitamin C content for the artichokes as a result of the manufacturing process, whether freezing or canning, also the biologically active substances was significantly affected, especially vitamin C and phenols in canned storage, compared to frozen storage.
4. The antioxidant activity, which measured by DPPH, was affected by all preliminarily treatments, especially the storage period which reduced the shelf life of antioxidant activity, and there was a correlation between the antioxidant activity and the total content of phenols which has been estimated by DPPH method.
5. Adding lower concentration of Citric Acid and calcium chloride salt maintained the chemical characteristics and the active biological compounds very well.

### II. Recommendations:

1. Best concentration and time for getting the perfect qualities for chemical and nutrition properties is adding 2% Citric Acid with 1% Calcium chloride salt for Artichoke with blanching for 10 minutes, Or adding 2% Citric Acid with 1- 2% Calcium chloride salt for Artichoke with blanching for 20 minutes.
2. The best method for preserving Artichokes is the freezing method, and best storage period is 3-6 months.
3. To keep on the vitamin, Artichokes should be blanched not for more than 10 minutes. However, to increase the phenolic content and take advantage of it, artichokes should be blanched for more than 10 minutes.

## References:

1. Boras, Mitiady, Abo Trabi, Bassam and Albasit Ebrahim. (2005). Vegetables and Crops Production. Damascus University Press.
2. Food and Agriculture Organization of United Nation (2005). FAO data 2005.
3. Samra, Mohammed Badie and Jalloul Ahmed. (2003). Production of summer vegetables. Tishreen University Press.
4. Abad Alegria, F. and Gonzalez Vivanco, P.(2004). The health and nutritional virtues of artichokes. Acta Hort . 660 :25-31.
5. Fratianni, F., Tucci, M., De palmia, M., Pepe, R, and Nazzaro, F. (2007). Polyphenolic composition in different parts of some cultivars of globe artichoke (Cyanara cardunculus L, var,scloymus (L) Fiori). Food Chem.104:1282 – 1286.
6. Halvorsen, B.L., Carlsen, M.H., Phillips, K.M. , Bøhn, S.K. Holte, K ., Jacobs Jr, D.R. and Blomhoff. R. (2006). Content of redox-active compounds (i.e. antioxidants) in foods consumed in the United States. Am. J. Clin. Nutr. 84:95-135.
7. Newall, C.(1996). Herbal Medicines. London, England: Pharmaceutical Press. pp. 36-37.
8. Del, N. MA., Conte, A., Scrocco, C., Laverse, J., Brescia, I., Conversa, G. and Elia, A. (2009). New packaging strategies to preserve fresh-cut artichoke quality during refrigerated storage. Innovat Food Sci Emerg Tech.10:128–133.
9. Atta, A.K.; GEED IPALL, I S.S.R., and ALMEIDA, M.F. (2005). Microwave combination heating. Food Technol.,pp:59- 36.

10. Food and Agriculture Organization of United Nation.(2003). Production year book. FAO, Rome. Italy, P.238.
11. Harris, L. J.(2002). Safe Methods of Canning Vegetables. ANR Publishers.University of California.U.S.A.
12. A.O.A.C (2006). Official methods of Analysis. In: Horwitz, W., Latimer, G.W. (Eds.), 2005 Current Through Revision 1. 18ed Maryland, USA.
13. Wada, L., and Ou, B. (2002). Antioxidant activity and phenolic content of Oregon caneberries. J. Agric. Food. Chem. 50: 3495-3500.
14. Asami, D.K., Hong, Y.J., Barrett, D.M. and Mitchell, A.E.(2004). Comparison of the total phenol and ascorbic acid content of freeze – dried and air dried Marino berry strawberry, and corn grown using conventional, organic and sustainable agricultural practices. J. Agric. Food Chem. 51:1237-1241.
15. Singh, R.P.; Chidambara, K.N., and Jayaprakasha, G.K. (2002). Studies on the antioxidant activity of pomegranate (Punica granatum) peel and seed extracts using in vitro models. J. Agric. Food. Chem. 50: 81-86.
16. A.O.A.C (2000). Official methods of Analysis of the Association of official Analytical Chemists, 17ed Maryland, U.S.A.
17. Dorfner, R., Ferge, T., Kettrup, A., Zimmermann, R. and Yeretzian, C. ( 2003). Real-time monitoring of 4-vinylguaiacol, guaiacol, and phenol during coffee roasting by resonant laser ionization time-of-flight mass spectrometry. Journal of agricultural and food chemistry. 51(19): 5768–5773.
18. Seow, C.C., and Lee, S.K.(1997). Firmness and color retention in blanched green beans and green bell pepper. J. Food Qual.20: 329–336.
19. Pellegrini, N., Chiavaro, E. Gardana, C., Mazzeo, T., Contino, D., Gallo, M., Riso. P., Fogliano, V. and Porrini, M.(2010). Effect of Different Cooking Methods on Color, Phytochemical Concentration, and Antioxidant Capacity of Raw and Frozen Brassica Vegetables. J. Agric. Food Chem. 58 (7):4310–4321.
20. Pereira Lima, G.P., Cardoso Lopes, T.V., Miranda Rossetto, M.R.,and Vianello, F.(2009). Nutritional composition, phenolic compounds, nitrate content in eatable vegetables obtained by conventional and certified organic grown culture subject to thermal treatment. International Journal of Food Science and Technology.44: 1118–1124.
21. Abdullah, Abdul Majeed Baggash. (2003). A comparison of the criteria used to determine the quality of some of refrigerated and frozen food. University of the Republic of Yemen.
22. Walter, W.M., Fleming, H.p., Thompson, R.L. and Fine, T.I. (1995). Effect of Sodium Chloride Concentration on Calciun uptakw into Brined Cucumbers. J. Agric.Food Chem. 25: 132-146.
23. Guillén-Ríaos , P., Burló, F., Martíanez-Sánchez, F. and Carbonell-Barrachina, A.A .(2006). Effects of Processing on the Quality of Preserved Quartered Artichokes Hearts. Journal of Food Science. 71(2): S176-S180.
24. Yaziji, Sabah and Azizieh Abdul Hakim. (2010). Effect of Preliminary Treatments on Spinach Quality During Freezing Storage. Damascus University Periodicals. Journal of Agricultural Sciences .26 (1): 277-292.
25. Lutz. M, Henriquez. C and Escobar.M (2011). Chemical composition and antioxidant properties of mature and baby artichokes (Cynara scolymus L.), raw and cooked. Journal of Food Composition and Analysis. 24(1): 49-54.
26. Sawyer, J. T., Apple, J. K. and Johnson, Z. B. (2008). The impact of lactic acid concentration and sodium chloride on pH, water-holding capacity, and cooked color of injection-enhanced dark-cutting beef. Meat Sci. 79:317-325.
27. Ikeda, H. and Ibaraki, T. (1998). Effects of atmosphere composition on respiration rates, chemical components and keeping quality of broccoli. Bulletin of the Fukuoka Agricultural Research Centre. 17: 102-105.
28. Wang, Z. P., Y. M. Lie and Z. Y. Fang. (2001). The changes in sugar, vitamin C and protein content in broccoli during storage. China vegetables. 2: 27-29.
29. Pereira Lima, G.P., Cardoso Lopes, T.V., Miranda Rossetto, M.R.,and Vianello, F.(2009). Nutritional composition, phenolic compounds, nitrate content in eatable vegetables obtained by conventional and certified organic grown culture subject to thermal treatment. international Journal of Food Science and Technology.44: 1118–1124.
30. Labuza, T. P., and Bin, Fu .(1997).Shelf Life Testing:Procedures and Prediction Methods. Chap. 19 in Frozen Food Quality . St. Paul. University of Minnesota.U.S.A, pp. 377-415.
31. Khayat, Ghassan Hamadeh and Mohammed Mohammed. (2001). Chemistry of food components. Damascus University Press.
32. Van Buren, J. P.(2007). The chemistry of texture in fruits and vegetables. Journal of Texture Studies. 10(1):1–23.

33. Puupponen-Pimia¨ , R., Ha¨kkinen, S., Aarni, M., Suortti, T., Lampi, A., Eurola, M.,Piironen, V., Nuutila, A. and Oksman-Caldentey, K.(2003). Blanching and long-term freezing affect various bioactive compounds of vegetables in different ways. Journal of Agricultural and Food Chemistry. 83:1389–1402.
34. Prior, R.L., Wu, X. and Schaich, K. (2005). Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements. Journal of Agricultural and Food Chemistry. 53: 4290–4302.
35. Sanchez-Mata, M. C., Camara, M., and Diez-Marques, C. (2003).Extending shelf-life and nutritive value of green beans (Phaseolus vulgaris L.), by controlled atmosphere storage: Micronutrients. Food Chemistry. 80: 317–322.
36. Giannakourou, M.C. and Taoukis, P.S. (2003). Kinetic modeling of vitamin C loss in frozen green vegetables under variable storage conditions. Food Chem. 83: 33-41.
37. Tosun, N.B., and Yucecan, S.(2007).Influence of Home Freezing and Storage on Vitamin C Contents of Some Vegetables. Pakistan Journal of Nutrition. 6 (5): 472-477.
38. Sebranek, J.G. (1996). Poultry and poultry products, Freezing Effects on Food Quality, Marcel Dekker, NY, USA, pp. 112-119.
39. Gil-Izquierdo, A., Gil, M.I. Conesa, M.A. and Ferreres. F. ( 2001). The effect of storage temperature on vitamin C and phenolics content of artichoke (Cynara scolymus L.) heads. Innovat. Food Sci. Emerg. Tech. 2:199-202.
40. Murcia. A. M, Jimenez.M.A and Martinez-Tome.M.(2009). Vegetables antioxidant losses during industrial processing and refrigerated storage. Food Research International.42(8):1046-4052.
41. Noroozi, M., Angerson, W.J. and Lean, M.E.(1998). Effects of flavonoids and vitamin C on oxidative DNA damage to human lymphocytes. Am J Clin Nutr. 67(6):1210-8.
42. Dudonné, S., Vitrac, X., Coutière, P., Woillez, M. and Mérillon, J.M. (2009). Comparative Study of Antioxidant Properties and Total Phenolic Content of 30 Plant Extracts of Industrial Interest Using DPPH, ABTS, FRAP, SOD, and ORAC Assays. *J. Agric. Food Chem*. 57 (5):1768–1774.


*****