COMPARATIVE EVALUATION OF THE EFFECTS OF FREEZING AND BOILING ON TOTAL PHENOLIC CONTENT OF THREE COMMONLY CONSUMED VEGETABLES

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Abstract

This paper studied the following species of vegetables: cauliflower (Brassica oleracea), broccoli (Brassica oleracea) and carrots (Daucus carota), through phytochemical analysis (total polyphenol content, ascorbic acid), in order to determine the influence of the storage processes (freezing/ blanching)and the boiling effect with usage in the food.

Freezing is the main method of preserving fruits and vegetables, in which most of the water from the cell juice of a product is transformed into ice.

The content of phenolic compounds was determined colorimetrically with the Folin–Ciocalteu (FC) reagent and was expressed in gallic acid equivalents (GAE). The result indicated that the concentration of crude protein in cauliflower and carrots was affected more after freezing and blanching than after freezing. The boiling treatment followed by freezing on cauliflower decreased to half the concentration of vitamin C while the freezing/ blanching treatment caused a minor lossof Vitamin C. From the preservation processes, a significant loss of total polyphenolic compounds was highlighted when the cauliflower was blanched and frozen. The results indicate that vegetables containing high ascorbic acid and phenolics may provide a source of dietary anti-oxidants.

Key words: Ascorbic acid, phenolics, freezing/ blanching, vegetables.

INTRODUCTION

The process of freezing and storing frozen food, fruits and vegetables changes their composition by reducing the nutritional value. Nutrients loss during freezing may be caused by the physical processes that occurring during the technological operations: removing bark splitting, washing, blanching, freezing and chemical changes that occur in products at the end of these operations.

The phenolic compounds are responsible for the major organoleptic characteristics of plant, in particular the color and taste properties. They are also known to contribute to the health benefits associated with the consumption of diets high in fruits and vegetables or plant-derived beverages (Lupoae M., et al., 2012). Cauliflower is know for its detoxification properties, has a low caloric content, but is rich in minerals, vitamins and antioxidants. Broccoli is an excellent source of vitamin A, B2, folate and vitamin C (2 times more vitamin C than an orange) and rich in iron and potassium.It is a vegetable with a high calcium content, almost an equivalent of milk in the diet. It contains selenium and sulfur compounds with important antioxidant and anticancer effects.

Storage and processing technologies have been utilized for centuries to transform these perishable fruits and vegetables into safe, delicious and stable products (Rickman, Joy C., et al., 2007).

Tissue dehydration is the most important negative effect of freezing. If the package is not effectively protected, the water is evaporated from the frozen product. The evaporation takes place both during freezing and during storage. The most important chemical changes are: change in pH, color, flavor, degradation of the composition of protein, loss of vitamins.

Cooking is defined as the heat treatment carried out on food to improve itspalatability, digestibility and safety. Although the temperature of cooking media reaches beyond 100^0C in somecooking methods, the temperature attained by the food when cooked is onlyabout 95^0C (Vaid, B. M., 2008). The initial thermal treatment of processed vegetables can cause loss of vitamin C.

Pellegrini N. et al., 2010 focused their investigation on the phytochemical content (carotenoids, chlorophylls, glucosinolates, polyphenols, and ascorbic acid), total antioxidant capacity (TAC) in Brassica vegetables. They analyzed fresh and frozen vegetables, demonstrating that the cooking procedures and boiling determined an increase of fresh broccoli carotenoids and fresh Brussels sprout polyphenols.

Similarly, Miglio C. et al., 2007 analyzed the effect of three common cooking practices (i.e., boiling, steaming, and frying) on three vegetables (carrots, courgettes, and broccoli) by evaluating the TAC values by different analytical assays [Trolox equivalent antioxidant capacity (TEAC), total radical-trapping antioxidant parameter (TRAP), ferric reducing antioxidant power (FRAP)] and the physicochemical parameters and observed an overall increase of antioxidant parameter values in all cooked vegetables.

Likewise, Gonçalves, E. M., et al. 2010 analyzed the content of total phenolic content degradation, color (CIEL*a*b*) and texture during hot water blanching treatments for carrots and concluded that the color changes of the vegetables during freezing are disagreeable because the plants become brown. The color changes are caused by the action of oxidative enzymes, namely polifenoloxidase and the flavonoid compounds. Action enzymes have adverse effects on the quality of the fruits and vegetables in the process of freezing, changing their characteristics, apart from color, nutritional value, vitamins and protein substances degrading and causing volatilization of flavors. Changes in the color are more intense in fruit and vegetables before freezing partitioned oxidation takes place than during the time of cutting and freezing. Blanching reduces the vitamin C content during processing, but limits further decreases during the frozen-storage phase of horticultural products (Lee et al., 2000).Nursal, B., and S. Yücecan, 2000, analyzed the content of vitamin C effected both by cooking methods and stewpansforfrozen spinach, peas, green beans and okra, and it was found that thawing before cooking is useless and causes more vitamin C loss.

The objective of the current study is to examine the effect of freezing and blanching in combination, on the brute protein, phenols and ascorbic acid of cauliflower, spinach and carrots with a view to their use as components of ready-meals.

MATERIALS AND METHODS

2.1. Plant material

Fresh cauliflower, broccoli and carrots were obtained from a local purchaser; the samples were stored at 4^{0}C before analysis.

Fresh cauliflower and carrots were cleaned by removing the inedible parts and then chopped into homogeneous pieces, leaving a stem of 2.5 cm.

To obtain more homogeneous samples, each vegetable was prepared in batches of 500 g. Each batch was then divided into three equal portions. One portion was retained raw; the others were blanchedin a thermostaticwater-bath (±1 ^{0}C) at 90 ^{0}C and afterwards collected after reaching pre-established time.The boiling time was 8 and 10 min for fresh cauliflower, broccoli and carrots.

Table 1

Botanical and common names of vegetables used for the analysis

Botanical name	Common name	Samples	
Brassica oleracea	cauliflower	S1	raw
		S2	frozen
		S3	boiled 8 min
Brassica oleracea	broccoli	S4	raw
		S5	frozen
		S6	Boiled 8 min
Daucus carota	carrots	S7	raw
		S8	frozen
		S9	boiled 10 min

Boiling. The fresh vegetables were added into boiling tap water in a covered stainless steel pot (1:5, food/water) and cooked on a moderate flame. The cooking time was 8, 10, and 10 min for fresh cauliflower, spinach and carrot respectively. The cooking time was measured starting from putting samples in the boiling water.

2.2. Chemical analyses

The dry matter determination was measured as described in Turkmen, N., et al., 2005. Due to the different water content of vegetables, all the calculations were performed according to dry matter basis. In order to determine the dry matter content, 3–4 g of raw, frozen or cooked homogenized using a high-speed blender sample (as triplicate) was dried in a convection oven at 70°C for at least 2 days until reaching constant weight.
The Total Kjeldhal nitrogen was determined from which protein contents were calculated by multiplying using the factor 6.25.
The total polyphenol content (TPC) of the extracts was determined by spectrophotometer, using gallic acid as standard, according to the method described by the International Organization for Standardization (ISO) 14502-1(ISO 2005; Singleton et al.1999). The results were expressed as mg of gallic acid equivalents (mg GAE).The correlation coefficient (r^2) for the calibration curve was 0.9954.
The Vitamin C in sample vegetables was determined by using 2, 6-dichlorophenolindophenol titration. The vitamin C contents of vegetables were reported as mg/100 g.

2.3. Chemicals

All chemicals used for experiments were of analytical grade and procured from Sigma Merck. Deionizer water was used. The absorption determination for total polyphenols content was made using UV–VIS spectrophotometer.

2.4. Statistical analysis

The statistical analysis was conducted with Excel Data Analysis for the 3 different samples (control, frozen and boiled respectively) extract from cauliflower, broccoli and carrots*)*.The experiments were made in three replicates and the results are expressed as mean ± standard deviation.

RESULTS AND DISCUSIONS

The results show the influence of conservation by freezing and the influence of cooking on some biochemical characteristics of the three studied vegetables: cauliflower, broccoli and carrot.

Protein content ranged from 2.2 and 0.94 % (table 2).

Table 2.

Sample's protein content

Protein %	raw	frozen	boiled 8 min
cauliflower	2.2[a]	2.15[a]	2.01
broccoli	0.98[b]	1.01[b]	0.94
carrots	1.21	1.01[c]	0.95[c]

means with the same superscript letter in the same line are not significantly different from one another (*Tukey's HSD, p-value < 0.05*).

The fresh cauliflower had 2.2% crude protein content, while after freezing 0.05% protein content was lost and after boiling the protein content decreased with 1.19%.

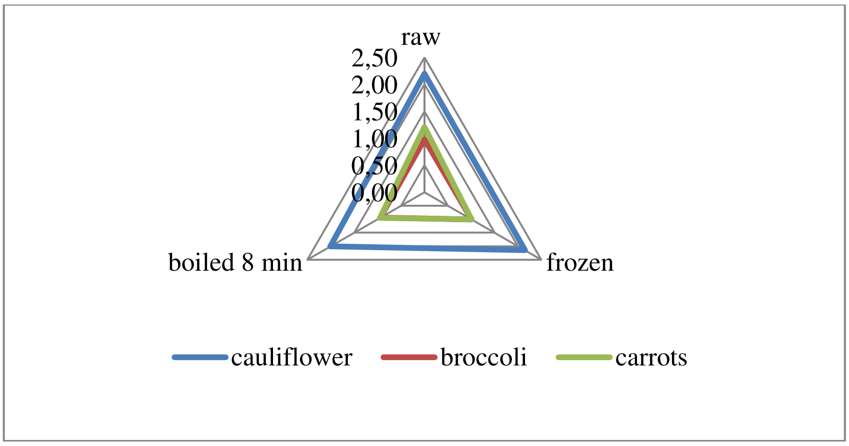

Fig. 1. Comparisions of protein content of vegetables samples

The concentration of crude protein inthe vegetables was affected more by the cooking process than by freezing, althoughboth treatments affected the protein content. However, the amount of crude protein loss confirms thatthe freezing process has a minimal effect on the protein content of cauliflower.

Total phenols.The results showed that the boiled broccoli extracts contained the highest content of poliphenols 1263.6 mg GAE/100 g(table 3).

Table 3.

Content of total polyphenols of samplesTP[a]

Botanical name	raw	frozen	boiled 8 min
Cauliflower	121.2	104.3	83.1
Broccoli	1245.1[a]	1240.2[a]	1263.6
Carrots	61.5[b]	60.1[b]	28.5

[a]TP = content of Total Polyphenols (mg GAE/100 g)
means with the same superscript letter in the same line are not significantly different from one another (*Tukey's HSD, p-value < 0.05*).

Ismail, A., et al., 2004 found that the total phenolic contents were very sensitive to heat treatment even for short cooking periods.Cauliflower is normally cooked by boiling before being eaten. Theraw cauliflower samples all had significantly higher total poliphenols 121.2 mg GAE/100 g than the frozen and boiled ones.

After analyzing the phenolics, ascorbic acid and carotenoids contents, the antioxidant activity of the broccoli floret and the stem and their changes during conventional and microwave cooking, it resultedthat the florets cooked conventionally for 30, 60,90, 120, and 300s lost 31.6%, 47.5%, 55.9%, 61.7%, and 71.9% respectively, of total phenolics present in the fresh floret, while the cooked stems lost 13.3%, 22.2%,26.7%, 28.9%, and 42.2%, respectively. (Zhang, D., & Hamauzu, Y., 2004).The free phenolic content values obtained are in agreement with the values reported by Kaur, C., et al., 2007.

Different reductions of **the ascorbic acid** content were observed in the analyzed vegetables samples (table 4).

Table 4.

Content of ascorbic acid mg /100g of analyzed samples

AA mg/100g	**raw**	**frozen**	**boiled 8 min**
cauliflower	83.12	65.02	40.21
spinach	20.8	23.6	18.67
carrots	31.2[a]	30.12[a]	18.52

means with the same superscript letter in the same lineare not significantly different from one another (*Tukey's HSD, p-value < 0.05*).

The levels of ascorbic acid in the freshly harvested cauliflower were high at 83.12 and 65.2mg/100g, respectively (table 4). After the freezing/blanching process more than 80% was retained, and there was little further loss (<10%) during subsequent frozen storage.

The greatest reduction in the content of ascorbic acid was in the cauliflower boiled 8 minute samples (51.62 %); followed by carrots boiled 10 minute (40.64 %).

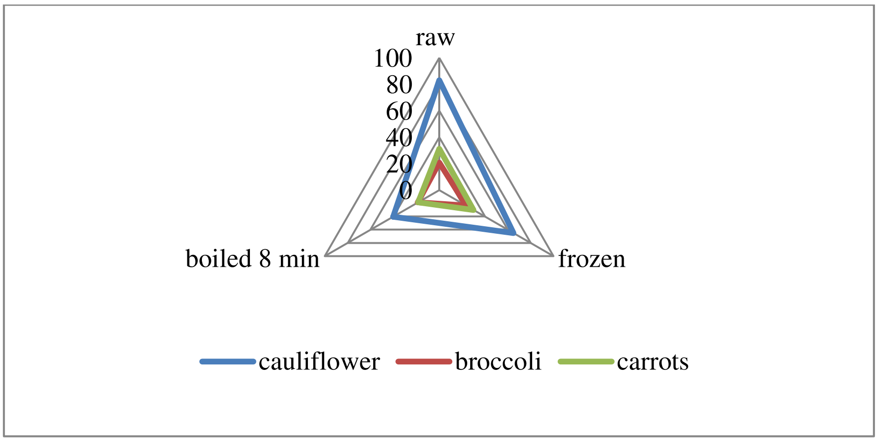

Figure 2.Comparisions of content of ascorbic acid mg /100g in the analyzed samples

Volden J. et al., 2009 recored important loss of ascorbic acid in a study performed on white, green and violet varieties of cauliflower.They have determined that blanching before freezing decreased on average the content of ascorbic acid with 19 % for all the three varieties of cauliflower, while freezing led to a drop in vitamin C on average with 24% in the case ofwhite and green varieties, but less for the violet variety.The violet cauliflower had less ascorbic acid loss than the other varieties because of the presence of anthocyaninswhich influence the stability of vitamins.

Following these observations, it can be concluded that blanching and freezing for cauliflower and carrot has a much greater effect on the content of ascorbic acid in comparison with plainfreezing.A study conducted by A. Patras, B. Et al., 2011 showed that after a rapid freezing, the content of ascorbic acid for the samples of carrot blanched and frozen was 40.6 mg/100 g, and for the samples of carrot that have undergone only freezing was 20.7 mg/100 g in comparison with raw carrots 43.9 mg/100g.

CONCLUSIONS

This study assessed the influence of freezing and blanching and freezing on the content of crude protein, ascorbic acid and polyphenols T0013765for cauliflower, spinach and carrot. The content of crude protein, vitamin C and polyphenols of frozen cauliflower, as well as in the case blanched and frozen cauliflower has been less than that of fresh cauliflower. The same trend was observed for the other two vegetables.

The loss of the active compounds is high during preservation by blanching followed by freezing. This loss should be taken into account when calculating the dietary intake for blanched and frozen cauliflower and broccoli.

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