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EFFECT OF THERMAL PROCESSING ON TOTAL PHENOLS, MYRICETIN AND QUERCETIN, VITAMIN C AND ANTIOXIDANT ACTIVITY OF SOME VEGETABLES

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ABSTRACT

The contents of total phenols and some flavonoids, vitamin C and antioxidant activity in freeze dried tissues of onion, cabbage, artichoke and sweet pepper in relation to the effect of two thermal processing treatments i.e. blanching and microwaving were studied. Vegetables were freeze dried after processing (more than the fresh ones) before hydrolyzed and extraction. Total phenols content in edible parts, was higher in sweet pepper but lower in onion. Thermal processing induced lowering effect on total phenols (mg / 100g) in onion, however, the effect by blanching exceeded those resulted from microwaving thermal treatment. Effects on these compounds but towards decrease were observed with microwave treatment in pepper and artichoke but in cabbage was increased. Meanwhile, blanching caused an increase in total phenols of sweet pepper as well as cabbage while in artichoke were slightly affected. The level of myricetin in cabbage exceeded those in onion and not detected in artichoke and pepper. Concerning the level of quercetin, it was obviously shown that sweet pepper the superior followed by artichoke and onion was contained the leowest quantities, however, it was not detected in cabbage leaves. Myriceten was sharply but negatively affected in cabbage leaves to be undetected by blanching and slightly by microwave treatment. On yellow onion tissues, this active material was quietly reduced by blanching and reversely responded by microwave treatment. The quercetin in artichoke as well as sweet pepper increased pronouncedly by blanching and also by microwave treatment but with a lower degree.

Sweet pepper fruits characterized by the highest percentages of vitamin C followed by that in the leaves of cabbage and the lowest content was in bulbs of onion. The highest effect of heat treatment was in onion followed by pepper and no response with cabbage tissues. Blanching tissues at boiling water for 5 min. decreased pronouncedly the level of vitamin C by 33.91, 53.85 and 2.70 % for pepper, onion and cabbage, respectively, *while* exposure to microwave thermal treatment decreased Vitamin C by 53.04 , and 69.23 % in sweet pepper and onion, respectively, while, cabbage tissues did not show any response with this treatment. The antioxidants activity were higher in pepper than the other tested vegetables. This activity raised in all vegetables except pepper by blanching and microwave.

Keywords: Total phenols – Myricetin – Quercetin - Vitamin C - Antioxidant activity - Thermal processing - Blanching - Microwave.- Onion - Artichoke - Cabbage - Sweet pepper.

INTRODUCTION

Phenolic phytochemicals are diverse groups of secondary plant metabolites and influence the sensory characteristics of food such as taste and flavor. Phenolic phytochemicals possess various health benefits such as antiproliferative, antimicrobial, anti-inflammatory and antioxidant effects (Middleton, *et al.* 2000; Surh, 2002; Gunduc and El, 2003, Kim *et al.*, 2003 and Kim *et al.*, 2004), and are commonly found in both edible and inedible plants and they have been reported to have multiple biological effects. (Shahidi *et al.*, 1992 and Kuti and Konuru, 2004)

Although flavonoids generally are considered to be nonnutritive agents, interest in these substances has arisen because of possible effects on human health (Hertog, *et al.* 1992). Current research shows that these flavonoids have antimutgenic and anticarcinogenic properties in experimental animal studies (Francis, *et al.*1989 and Deschner, *et al.* 1991).

Flavonols and flavones occur mainly in the leaves and outer parts of the plants, while only trace amounts are found in parts of the plants below the soil surface (Herrmann, 1988). In vegetables, quercetin glycosides predominant, but glycosides of kaempferol, luteolin, and apigenin are also present. Flavonoids were studied in pepper by Lee, *et al.* (1995), in onion by Nuutila, *et al.*(2002), Marotti and Piccaglia (2002) and Shon *et al.* (2003), in Cabbage by Kim, *et al.* (2004) and different vegetables and fruits by Ewald, *et al.*(1999) and Justesen, *et al.*(1998).

As a large number of different glycosides are present in foods, the quantitative determination of individual flavonoid glycosides in vegetables and fruits commonly consumed would be complicated. In addition, because of low levels of individual flavonoid glycosides in foods and the limitations indicated, completeness of hydrolysis and extraction, only analysis of the aglycons after hydrolysis proved to be a practical method for the quantitative determination of flavonoids in food (Hertog, *et al.* 1992).

Although much remains to be learned about flavonoids content in different foods, even less is known about the effect of processing on flavonoid content. Ewald, *et al.* (1999) studied the effect of blanching, water cooking, microwave and frying on flavonoids in onion, peas and green bean. Gayathri, *et al.* (2004), studied the effect of pressure cooking and open boiling on onion, amaranth and carrot. Agostini, *et al.* (2004) studied the effect of different thermal processing on the antioxidant capacity of flavonoids in onion and some fruits and Kaur and Kapoor (2001) reported the importance of total polyphenols and other phytochemicals present in vegetables and fruits implicated as antioxidants (carotenoids, vitamin E and vitamin C) and the improving of the antioxidant status of processed foods.

Therefore, this study was designed to investigate the effect of some thermal processing i.e. blanching and microwaving on the content of total phenols, quercetin, and myricetin (flavonoids) and vitamin C in some vegetables.

MATERIALS AND METHODS

Raw materials

Onion (*Allium cepa L*), Sweat pepper (*Capsicam annuum L*), artichoke (*Cynara scolymus L*) and Cabbage (*Brasssica oleracea var capitata L*) were purchased from the local market in Giza Governorate.

Thermal processing

The edible parts of every vegetable were cleaned, washed and chopped in a food processor, divided for three parts, the first part was the fresh vegetables used as a reference sample. The second part of samples was blanched in a vessel for 5 min in the presence of water and the third part of samples were subjected to microwave oven in a vessel containing water for 5 min.

Sample preparation

After the two heat treatments samples were cooled in ice water and frozen in a flow -freezer. The three frozen samples were moved to a freeze-dryer and lyophilized then ground and stored at -18 ◦C until analysis. The samples used for vitamin C determination did not freeze dried.

Determination of total phenols

Samples were analyzed spectrophotometrically for the content of total phenolic compounds using a modified Folin- Ciocalteu colorometric method (Singelton. *et al*, 1999) .UV-160PC, UV-Visible spectrophotometer SHIMADZU, Japan was used for reading samples and stander material.

Determination of flavonoids

Extraction and hydrolysis

The standard procedure for hydrolysis and extraction of flavonoids from vegetables was as follows: 40 mL of 62.5 aqueous methanol was added to 0.5 g of freeze-dried sample material, 10 mL of 6 M HCL was added with careful mixing. The extraction solution thus obtained consisted of 1.2 M HCL in 50 % aqueous methanol (v/v). After refluxing at 90 ◦C for 2 hours with regular swirling, the extract was allowed to cool and was subsequently made up to 100 mL with methanol and sonicated for 5 min to remove oxygen before injection. Approximately 2 mL was filterated through a 0.45 um filter for ornic solvent (Acrodisc CR PTFE, Gelmn) prior to injection (Hertog, *et al.* 1992 and Ewald, *et al.* 1999).

Standards

The two flavonoids used as standards were flavonols, quercetin, and myricetin from Fluka. The standards were dissolved in methanol to a concentration of 500 µg ml^-1 as stock solution and stored at 4 ◦C. Calibration with concentrations between 0.1 and 25 µg ml^-1 were prepared by diluting an aliquot of the stock solution with 20 ml 62.5 % aqueous methanol with 2 mg ml^-1 of the antioxidant tert-butyl hydroquinone (TBHQ)), 5 ml 6 M HCL and methanol up to 50 ml (Ewald, *et al.* 1999).

Determination

Samples were analyzed using SHIMADSU LC-4A. Separation were carried out using a reversed phase column (250 f 46 mm). The mobile phase consists of 30 % of acetonitrile in 0.025 M KH_2P0_4 (pH 2.4) with flow rate of 1.3 min (Ewald, *et al.* 1999). Flavonoids were monitored at a wavelength of 340 nm.

Ascorbic acid (Vitamin C)

Ascorbic acid content was determined in fresh and processed samples of cabbage, onion and sweet pepper by using 2-6 dichlorophenol indophenol dye and 3 % oxalic acid as a substrate. Ascorbic acid was calculated as milligrams per 100 milliliters of juice (A.O.A.C., 1995).

Antioxidants activity

Antioxidant activity was determined according to the method described by Lee, *et al.* (1995) how used the method of Tega *et al.*(1984) with some modifications in which antioxidant activity was expressed as % inhibition relative to the control.

RESULTS AND DISCUSSION

The content of total phenols, some flavonoids, ascorbic acid and antioxidant activity of these compounds were determined in some vegetables tissues i.e. onion, cabbage, artichoke and pepper, also the effect of blanching and microwaving on these compounds was studied. The results are presented as follows:

Total Phenols

Total phenols content of the edible parts of vegetables used in this work were illustrated in Table (1) and Fig.(1).Total phenols content, the higher was in sweet pepper and the lower was in onion (after removing the outer layers) and for cabbage and artichoke were in between but the values of these two vegetable crops were 146.2 and 140.4 mg/100g and without significant difference.

Table (1): Effect of thermal processing on total phenols of some vegetables (mg/100g).

Thermal processing	Onion	Artichoke	Cabbage	Sweet pepper	Mean
Raw	85.4	140.2	121.2	396.1	168.2
Blanched	65.5	165.2	161.5	418.7	202.7
Microwave	72.9	133.1	138.6	291.4	159.0
Mean	74.6	146.2	140.4	345.4	

L.S.D. at 5% for: species: 35.36 Thermal processing: N.S Interaction: N.S

The effect of thermal processing and total phenols content was presented in Table (1). Thermal processing induced lowering effect on total phenols (mg / 100g) in onion, however, the effect by blanching exceeded those resulted from microwave thermal treatment. Furthermore, effects on these compounds, but towards decrease, were observed with microwave on pepper and artichoke and towards increase in the case of cabbage. Meanwhile, blanching showed an increase in total phenols of sweet pepper as well as cabbage while these active materials in artichoke were also affected. *Jianmei-Yu, et al.(2005)studied the effect of processing methods on* concentration and antioxidant activity of peanut skin phenolics and found that blanching caused a significant loss of total phenols. However, Kuti, *et al* (2004) revealed that the total phenolic and antioxidant capacity was much higher in raw fresh leaf extracts than that in cooked leaf extracts. Meanwhile, Dewanto, *et al.* (2002) noticed that there were no changes in total phenols in tomato with thermal treatment at 88 ∘C. Nevertheless, Chism and Haard, (1996) found that phenolic acids occur in plants as metabolic intermediates and they also accumulated in vacuoles. Thermal processing may release more bound phenolic acids from breakdown of cellular constituents and this may be intern as increase of phenolic compounds by thermal processing.

Flavonoids

Flavonoids can play a great role as metal chelators and reducing agents, as chain-breaking antioxidants, as scavengers of reactive oxygen species and as quenchers of the formation of singlet oxygen (Kandasawami and Middleton, 1994). Plant use flavonoids for protection against oxidative damage by inhibiting or quenching free radicals and reactive oxygen species (Larsen, 1988).

Myricetin and quercetin contents in artichoke, cabbage, onion and sweet pepper represented (as mg /100 g DM) are presented in Table (2). In fresh samples the level of myricetin in cabbage exceeded than that in onion and not detected in artichoke and pepper. Concerning the level of quercetin, generally, it was obviously shown that sweet pepper contained the highest content followed by artichoke and onion was contained the lower quantities, however, it not detected either fresh or processed cabbage leaves. Teresa *et al* (2000) stated that total flavanol contents varied from non detectable in most of vegetables to 184 mg/100g found in samples of broad bean.

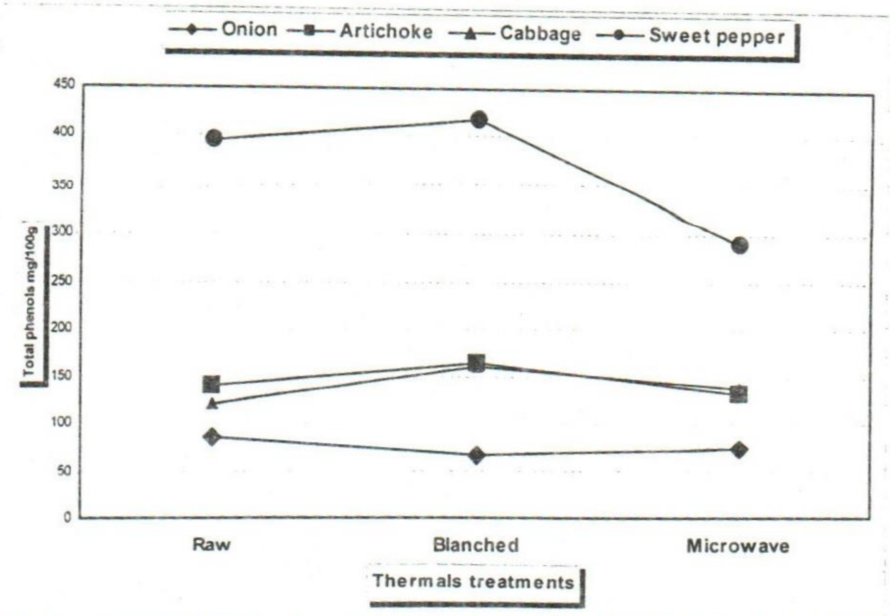

Fig (1): Effect of thermal processing on total phenols of some vegetables (mg/100g).

Marotti and Piccaglia (2002) estimated flavonoids yield in different onion varieties and mentioned that it ranged from 1.13 to 5.23 g/m^2 Justesen, *et al.* (1998) determined the different flavonoids in vegetables and fruits and they found that on red onion, spring onion and yellow onion contained 45±21, 18±12 and 34±7 mg/100 g quercetin, respectively, while green sweet pepper contained 0.5 mg /100 g, meanwhile this compound not detected in red sweet pepper and yellow sweet pepper. Ewald, *et al.* (1999) reported 41 mg/100g quercetin in onion. Hertog, *et al.* (1992) in different vegetables and in four periods from April, 1991 to April, 1992, noticed that quercetin in onion tissues was 347±65 mg / 100 g and in red cabbage was 6±1.1 mg/100g but not detectable in green cabbage. Franke, *et al.* (2004) found that myricetin ranged from 0.4 to 12.0 mg/kg and quercetin ranged from 0.2 to 4.0 mg/kg in yellow and red cabbage. However, quercetin ranged from 0.4 in yellow onion to 38 in red onion and from 0.2 in pak choi to 4.0 mg/kg in red cabbage.

Table (2): Effect of thermal processing on myricetin and quercetin of some vegetables (mg/100g).

Species	Thermal processing	Myricetin	Quercetin
Onion	Raw	26.6	5.45
	Blanched	21.53	N.D
	Microwave	36.55	84.23
Cabbage	Raw	62.1	N.D
	Blanched	N.D	N.D
	Microwave	56.4	N.D
Artichoke	Raw	N.D	13.6
	Blanched	N.D	47.89
	Microwave	N.D	21.80
Sweet pepper	Raw	N.D	157.88
	Blanched	N.D	300.01
	Microwave	N.D	170.35

Myricetin and quracetin flavonoids responded differently to the type of heat treatment and in what crop were measured. Myricetin was negatively and sharply affected in cabbage leaves which disappeared completely by blanching and slightly affected by microwaving treatment. On yellow onion tissues this active material was quietly reduced by blanching and reversely responded by microwave thermal treatment. The quercetin in artichoke as well as sweet pepper increased pronouncedly by blanching and, also by microwave heat treatment but with a lesser degree.

The effect of thermal processing on phenols and antioxidants in vegetables and fruits were studied by some authors. Biga, *et al.* (2003) found that drying fresh plums at 85 – 95 °C for 18 hrs destroyed anthocyanins and significantly reduced flavonoids. Franke, *et al.* (2004) determined ascorbic acid and flavonoids i.e. the major dietary flavones, flavonols, flavonones and anthocyanidins and indicated that storage and processing, especially when heat was applied, led to significant losses of all these compounds. This may be attributed to effect of heat in pathway of flavonoids or enzymes activity worked in it (Chism and Haard, 1996 and Dewanto, *et al* 2002). On the other side, for the view in which thermal treatments raised the content of flovonoids. Dewanto, *et al.* (2002) indicated that thermal processing may be enhanced the nutritional value of tomatoes by increasing the bioaccessible lycopene content and total antioxidant activity and are against the notion that processed fruits and vegetables have lower nutritional value than fresh products. Kuti, *et al.* (2004) demonstrated that the predominant flavonoid, increased by ≈ 23 % in the cooked leaf samples when compared to the raw leaf samples of spinach. Kaur and Kapoor (2001) support the hyposis's of the improving of the antioxidant status of processed foods.

Ascorbic acid (Vitamin C)

Data recorded in Table (3) show the levels of vitamin C in the different vegetable crops i.e. sweet pepper, onion, and cabbage. For fresh samples, sweet pepper fruits characterized by the highest percentages of vitamin C followed by that in the leaves of cabbage and the lowest percentage was in bulbs of onion. Lee, *et al.* (1995) mentioned that peppers are a good source of vitamins C, and as consumption increases, pepper may contribute notable amounts of vitamins A and C and flavonoids to the diets. Franke, *et al.* (2004) pointed out that vitamin C ranged from 188 to 283 mg/kg and in yellow onion ranged from 42 – 84 mg/kg.

Table (3): Effect of thermal processing on vitamin C content of some vegetables (mg/100mL).

Thermal processing	Onion	Cabbage	Sweet pepper	Mean
Raw	15.6	44.4	276.0	112.0
Blanched	7.2	43.2	182.4	77.6
Microwave	4.8	44.4	129.6	59.6
Mean	9.2	44.0	196.0	

L.S.D at 5% for: species: 26.16 Thermal processing: 7.11 Interaction: 12.37

Table (3) and Fig.(2) show the effect of thermal treatments on the content of vitamin C in tissues of some vegetables.. Vitamin C was responded negatively to the thermal processing. Data also, revealed that the highest effect of blanching treatment was in onion followed by pepper and approximately with no response in cabbage tissues in comparable with that in fresh samples. Microwave treatment exerted relatively the same response but in great degree. Howard, *et al.* (1994) concluded that ascorbic acid in peppers varies according to maturity and processing. Puuponen, *et al.* (2003) revealed that up to one-third of vitamin C content was lost during blanching. Wong, *et al.* (2003) stated that ascorbic acid and anthocyanins can be easily destroyed during processing. Canet, *et al.* (2004) mentioned that more ascorbic acid retained when samples were stir-fried than when they were boiled. This means that not only the heat degree or time of exposure affected vitamin C but also by the method of cooking. Franke, *et al.* (2004) also, observed the reduction of ascorbic acid content in cabbage and yellow onion by cooking.

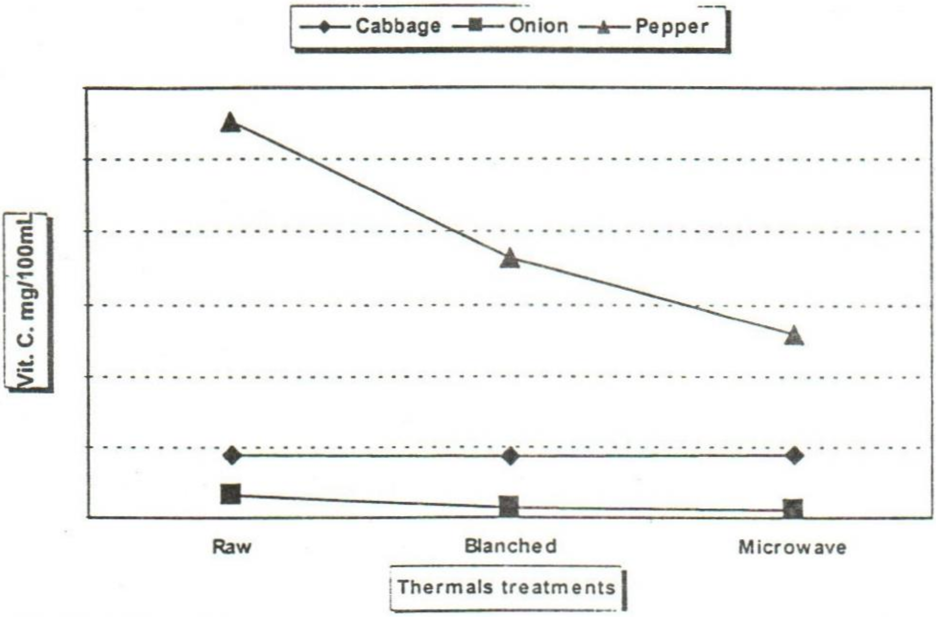

Fig (2): Effect of thermal processing on vitamin C content in some vegetables.

Data in Table (3) show the effect of thermal treatments on ascorbic acid content of different vegetable crops. Blanching tissues in boiling water for 5 mins decreased pronouncedly the level of vitamin C by 33.91, 53.85 and 2.70 % for pepper, onion and cabbage while subjection to microwave thermal treatment decreased Vitamin C by 53.04 , and 69.23 % for sweet pepper and onion, respectively, while, cabbage tissues did not show any response with this treatment. Losses of vitamin C occurred primarily by chemical degradation that involved oxidation of ascorbic acid to dehydro-ascorbic acid (DHAA), followed by hydrolysis to 2,3-diketogulonic acid and further polymerization to form other nutritionally inactive products (Gregory, 1996). Furthermore, Thudnatkorn-Jiratanan and Rui-Hai-Liu (2004) emphasized that antioxidative activity of beets processed under typical commercial conditions remained constant, despite an 8% loss of vitamin C and there was a slight but significant 5% increase in the total phenols present in processed beets. In green beans, vitamin C content remained constant, whereas, phenols and antioxidative activity reduced by 32 and 20%, respectively.

Belesten (2001) discussed the health benefits associated with consumption of fruits and vegetables together with the potential physiological effects of various plant components. He concluded that these were done through the epidemiological evidence linking high intake of fruits and vegetables with increased protection against disease; phytochemicals (carotenoids, glucosinolates and flavonoids) with potential protective effect and role of these components in the protection of DNA against oxidative damage of free radicals.

Antioxidant activity

Free radicals have been reported to do oxidative damages of biological systems, which cause human degenerative diseases such as cancer, heart disease and Alzheimer's disease (Kim, *et al.* 2004).Yu, *et al.* (2002) emphasized that a balance between formation and removal of reactive oxygen species or radicals is required to maintain normal physiological functions for human health. Many authors reported a benefical effect of cooking on antioxidants (Kaur and Kapoor, 2001, Dewanto, *et al.*, 2002 and Piga, *et al.* 2003)

The antioxidant activity in different freeze dried vegetables i.e. onion, cabbage, artichoke and pepper and its response to thermal processing was presented in Table (4).(Antioxidant activity was determined using B-carotene and linoliec acid, the activity expressed as % inhibition relative to the control).Antioxidant activity in fresh samples (raw) showed that it approximately equal in cabbage, onion and artichoke but higher in pepper. Tomas-Berberan and Espin (2001), Howard, *et al.*(2002) and Kuti and Konuru (2004) reported that, genetic makeup appears to play an important role in phenolic metabolism and antioxidant capacity in fruits and leaf green vegetables.

In general, thermal treatment caused an effect on antioxidant activity as shown in Table (4). The general mean of thermal methods values indicated that blanching and microwaving slightly higher in its effect on antioxidant activity. Sluis *et al* (2004) stated that previous research has shown that conventional apple juice processing resulted in a juice poor in flavonoids and with low antioxidant activity. Thudnatkorn and Lui (2004) pointed out that in green beans, vitamin C and dietary folate content remain constant whereas phenols and antioxidative activity were reduced by 32 and 20 %.They added that antioxidative activity of beets processed under typical commercial conditions remained constant despite an 8% loss of vitamin C and 30 % loss of dietary foliate. However, Chu, *et al.* (2000) mentioned that blanching for 30 to 60 s allowed retention of flavonoids and free radical scavenging activity. On the other hand, Piga, *et al.* (2003) demonstrated that drying at 85 °C doubled antioxidants activity in both cultivars of plumbs, while condtradictory results were found for 60 °C processed plumbs. Dewanto, *et al.* (2002) showed that lycopene content and total antoxidant activity significantly increased with thermal processing despite the nonsignificant changes in the total phenolic and total flavonoid contents and the decline in vitamin C content in heat-processed tomatoes.

Table (4) : Effect of thermal processing on antioxidant activity in some vegetables (%)

Thermal processing	Onion	Artichoke	Cabbage	Pepper	Mean
Raw	46.51	41.32	44.98	64.51	49.33
Blanching	54.21	47.55	63.91	50.31	53.25
Microwave	59.22	51.25	55.15	49.33	53.74
Mean	53.31	46.71	54.65	54.72	

The interaction effect of species differences and thermal treatments in antioxidant activity were recorded in Table (4). Data cleared that blanching increased this activity in cabbage, onion and artichoke. The increment in onion and artichoke approximately equal. On reverse, this thermal treatment depressed clearly the antioxidant activity in pepper.

Dewanto, *et al.* (2002) indicated that thermal processing my be enhanced the nutritional value of tomatoes by increasing the bioaccessible lycopene content and total antioxidant activity and are against the notion that processing fruits and vegetables have lower nutritional value than fresh produce.. Kaur and Kapoor (2001) support the hypnosis's of the improving of the antioxidant status of processed foods.

The varied response of antioxidant activity may be attributed to the different correlations with antioxidants attributes. In this concern, in spite of that mentioned by: Care, *et al.*(2004) revealed that the antioxidant capacity, moreover, was clearly correlated with the ascorbic acid content rather than with the presence of flavanone glycosides. Yamaguchi, *et al.*(2003) concluded that the decrease of activity in broccoli depended on the oxidation of ascorbic acid by ascrobate oxidase. None of these compounds decreased after the enzymes had been inactivated by heating. Lee, *et al.* (1995) stated that phenolic compounds including pepper flavonoids can contribute to antioxidant activity. Neverthless, Dewanto, *et al.* (2002) noticed that this may be due to the additive and synergy effects of other phytochemicals such as phenolic and flavonoids. Moreover, Chism, *et al.* (1996) observed that thermal processing may release more bound phenolic acids from the breakdown of cellular constituents. Although disruption of cell walls also release the oxidative and hydrolytic enzymes that can destroy the antioxidants in fruit and vegetables. Thermal processing at 88 °C deactivates these enzymes to void the loss of phenolic acids.

Conclusion

The effects of thermal processing vary with vegetable type and reinforce the concept that optimal health benefits may be achieved when a wide variety of plant foods and preparation methods are incorporated into the diet. This due to the variation in response in phytochemicals which increased in some vegetables and decreased in others as a response to thermal processing. Moreover, In spite the depressive effect in vitamin C, cooking had a beneficial effects. This subject also open up more opportunities for the food processing industry.

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تأثير المعاملات الحرارية على المحتوى الكلى للفينولات والمرستين والكيورستين وفيتامين ج ونشاط الأكسدة فى بعض الخضروات

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اجريت هذة الدراسة بهدف دراسة تاثير المعاملة الحرارية بالسلق والميكروويف على المحتوى الكلى للفينولات وبعض الفلافونات ومضادات الأكسدة فى عينات البصل والكرنب والخرشوف والفلفل المجفدة. كما قدر فيتامين ج فى العينات الطازجة والمعاملة حراريا من الفلفل والكرنب والبصل ايضا واظهرت النتائج ان:

أعلى نسبة من الفينولات فى الأجزاء المأكولة كانت فى الفلفل بينما الأقل كانت فى البصل. ادت المعاملة الحرارية الى انخفاض فى محتوى الفينولات فى انسجة البصل وكان الانخفاض بمعاملة السلق اكبرمن معاملة الميكروييف. كما ادت هذة المعاملات الى تغيرات محدودة على هذة المركبات وفى اتجاه الانخفاض مع معاملة الميكروييف فى الفلفل والخرشوف ولكن زادت فى حالة الكرنب. كما ادى السلق الى زيادة الفينولات الكلية فى الفلفل والكرنب بينماكان التاثير على الخرشوف قليلا. زاد محتوى الميرستين فى الكرنب عن البصل بينما لم يظهر فى كل من الفلفل والكرنب. تميز الفلفل باحتوائة على اعلى كمية من الكيورستين يلية الخرشوف ثم البصل الذي احتوى على اقل كمية منة.

استخدام السلق ادى الى تاثر المرستين سلبا وبدرجة كبيرة فى الكرنب لدرجة الأختفاء بينما كان التاثر قليلا باستخدام معاملة الميكروييف، فى انسجة البصل اختفى هذا المركب بالسلق وكانت الأستجابة عكسية عند استخدام الميكروييف. وزاد الكيورستين فى كل من الخرشوف والفلفل بدرجة ملموسة بمعاملة السلق وكذلك معاملة الميكروييف ولكن بدرجة أقل.

ولقد تميز الفلفل باحتوائة على اعلى نسبة من فيتامين ج يلية الكرنب اما البصل فكان أقلها احتواءا على هذا الفيتامين .وكان أعلى تأثير للحرارة على فيتامين ج فى البصل يلية الفلفل بينما لم يكن هناك تاثيرا يذكر فى حالة الكرنب. ادى السلق فى الماء المغلى لمدة ٥ دقائق الى خفضا كبيرا فى كمية فيتامين ج وبنسبة ٣٣,٩١ % و٥٣,٨٥ %و ٢,٧٠ % فى كل من الفلفل والبصل والكرنب على التوالى بينما نسبة الأنخفاض فى الفيتامين باستخدام الميكروييف كانت ٥٣,٠٤ %و ٦٩,٢٣ % فى كل من الفلفل والبصل على التوالى. فى حين لم يكن هناك اى اختلاف بين المعاملتين او معاملة المقارنة فى أنسجة الكرنب.

نشاط مضادات الأكسدة كان مرتفعا فى الفلفل عن بقية الخضروات المختبرة. وارتفع هذا النشاط فى كل الخضروات المختبرة ماعدا الفلفل بمعاملتى السلق والميكروييف.