American Journal of Food and Nutrition, 2015, Vol. 3, No. 5, 125-130
Available online at http://pubs.sciepub.com/ajfn/3/5/3

DOI:10.12691/ajfn-3-5-3

Effect of Domestic Processing Methods on the Chemical Composition and Organoleptic Properties of Broccoli and Cauliflower

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Abstract This study was carried out to investigate the effect of three domestic processing methods (blanching in boiled water, steaming and microwaving) on chemical composition, minerals, color and organoleptic properties of broccoli (*Brassica oleacea* var *italica*) and cauliflower (*Brassica oleracea* var. *botrytis)*. The results of proximate chemical composition showed that broccoli had a lower moisture and higher dry matter, crude protein, crude fat and ash compared with cauliflower, while cauliflower had higher content of carbohydrate than broccoli. Blanching in boiled water, steaming and microwaving methods caused a significant increasing in moisture content and a significant decreasing in crude protein, crude fat, and ash content of both broccoli and cauliflower (on dry weight basis), meanwhile no significant effect was observed in carbohydrate content of broccoli and cauliflower after processing except that of steamed cauliflower it had lower content of carbohydrate than broccoli. However, the change in crude fiber content was not significant due to processing when calculated on dry weight bass. It was found that, fresh cauliflower had a higher content of Fe and Ca than fresh broccoli while the opposite was observed in case of Zn, Mg, K and Na content (on dry weight basis). Different processing methods resulted in significant reduction in the mineral contents in both broccoli and cauliflower comparing with the fresh ones. Broccoli tends to be from green to blue while cauliflower tends to be yellow in color. Fresh broccoli color was higher in purity comparing to the processed ones. The lowest purity value was noticed for microwaved broccoli. Steamed cauliflower color had the highest L (lightness) value and lowest one was observed for microwaved samples. Sensory evaluation showed that both raw and processed cauliflower and broccoli were acceptable by panelists.

Keywords: *broccoli, cauliflower, chemical composition, minerals, organoleptic properties*

Cite This Article: Abd Allah Mansour, Nahed M.Elshimy, Laila A. Shekib, and Magda S. Sharara, "Effect of Domestic Processing Methods on the Chemical Composition and Organoleptic Properties of Broccoli and Cauliflower." *American Journal of Food and Nutrition*, vol. 3, no. 5 (2015): 125-130. doi: 10.12691/ajfn-3-5-3.

1. Introduction

Vegetables are the fresh and edible portions of herbaceous plants. They are important food and highly beneficial for the maintenance of health and prevention of diseases. They contain valuable food ingredients which can be successfully utilized to build up and repair the body. Vegetables are valuable in maintaining alkaline reserve of the body. They are valued mainly for their high vitamin and mineral contents. There are different kinds of vegetables. They may be edible roots, stems, leaves, fruits or seeds. Each group contributes to diet in its own way [1]. Moreover plant derived foods such as vegetables are a significant source of nutritional antioxidants (vitamins and carotenoids), as well as biologically active dietary components (flavonols, hydroxycinnamic acids) and sulphur-containing compounds such as glucosinolates (GLs) [2]. Vegetables contribute minerals, vitamins, and fiber to the diet. Minerals are naturally occurring inorganic substances with a definite chemical composition and an ordered atomic arrangement. Among the plants, vegetables are the excellent sources of minerals and contribute to the recommended daily allowance (RDA) of these essential nutrients. Minerals are very important and essential ingredients of diet required for normal metabolic activities of body tissues. Out of 92 naturally occurring minerals 25 are present in living organisms. They are constituent of bones, teeth, blood, muscles, hair and nerve cells. Vitamins cannot be properly assimilated without the correct balance of minerals [3].

Broccoli (*Brassica oleracea* L., *Italica*) is a good vegetable source of Ca and Mg, two critical minerals in human nutrition. Studies have shown that bioavailability of Ca from broccoli is comparable to that from milk. [4] Also it was found that, broccoli is a good source of the macro mineral elements; such as Na, K, Ca, Cl, P, and S and trace elements; such as Fe, Zn, Mn, and Cu that are essential for the human being [5]. Water blanching process had a great effect on the nutrient components and caused significant losses of dry matter, protein, and mineral and photochemical contents in broccoli and cauliflower. However, steam treatments and microwaving presented the lowest reductions [6]. The same author stated that, the protein, ether extract, ash and fiber

reduction was the highest in the case of water boiled followed by steam boiled and the lowest reduction in the above mentioned nutrients was for the microwaved samples in both of broccoli and cauliflower. The significant parameters are the temperature, the length of thermal processing and the pH of the medium in which the pre-treatment is carried out [7].

This study was carried out to evaluate the effect of domestic processing methods (Blanching in boiled water, steaming and microwaving) on the chemical composition, minerals, colour, and organoleptic properties of both broccoli and cauliflower.

2. Materials and Methods

2.1. Plant Material

Fourteen kilogram of Broccoli (*Brassica oleracea* var. *italica*) was purchased from a farm in Housh Eissa (El Behiera Governorate, Egypt) and same amount of cauliflower (*Brassica oleracea* var. *botrytis*) was purchased from local market in Alexandria.

2.2. Processing of Broccoli and Cauliflower:

-Each of broccoli and cauliflower samples were washed and cut into flowers of 2-3 cm length from the top of the stem (florets). Then each of broccoli and cauliflower florets were divided in to 4 parts and the process was completed as following:-.

Pre-experiments were carried out as trails to adjust the optimum conditions for preparing the blanched broccoli and cauliflowers.

1- Blanching in boiled water: - broccoli and cauliflower samples were divided into three parts each weight, 50 g and put in 500 ml of boiled water and blanched for (4,6 and 8 min). Then each of the blanched broccoli and cauliflower samples were cooled in iced water to prevent over cooking.

2- Steaming process: - florets samples (broccoli and cauliflower) were divided to three parts, 50 g weight of each and steamed on boiled water vapor for (12, 14 and 16 min) also the steamed samples were cooled in iced water to prevent over cooking.

3- Microwave cooking process:- florets of each of broccoli and cauliflower samples were divided into three parts 50 g weight of each and put in microwave (model: Micro-Chef FM 2935Q, 2450 MHz. Input 1400 W, Output 900 W) containing 200 ml boiling water for (2,4 and 6 min). Similarly as mentioned above the samples were cooled under iced water to prevent over cooking.

All the cooked broccoli and cauliflower by blanching in boiled water, steamed or microwaved were subjected to taste panel testing using composite scale system as mentioned by Kramer and Twigg [8].

10 taste panel panelists were used in tasting and judging the samples. The optimum time for each treatment were chosen as the most preferable samples as judged by the taste panelists.

2.3. Proximate Chemical Composition

All analysis were carried out in triplicates determination and expressed on wet and dry basis, unless otherwise stated. Moisture, crude protein, crude lipid, crude fibers, total ash were carried out according to the AOAC [9] procedures. Carbohydrates were calculated by difference.

2.4. Minerals

The minerals were determined according to the method described in AOAC [9] Fe, Zn, Ca and Mg were determined using Perkin-Elmer 2380 Atomic Absorption spectrophotometer. Na and K were estimated by clinical flame photometer 410 ˚C (Corning).

2.5. Color

Color of broccoli and cauliflower was measured by Hunter lab ultra scan VIS. Hue and purity were calculated using the following equation

$$\text{Hue}=a/b \qquad \text{purity} = \sqrt{a^2 + b^2}.$$

2.6. Organoleptic Properties

Color, odor, taste, texture and over all acceptability of broccoli and cauliflower samples were evaluated by ten panelists of Food Science and Technology Department, Faculty of Agriculture, Alexandria University, Egypt, using a numerical (hedonic) rating of 1-10 (1=dislike very much, 10=like very much) as described by Kramer and Twigg [8]**.**

2.7. Statistical Analysis

Data were statistically analyzed using randomized complete block design (R.C.B.D). Comparisons between means were carried out using least significant difference at 0.05 probability level ($LSD_{0.05}$) according to Steel and Torrie [10].

3. Results and Discussion

3.1. Proximate Chemical Composition:-

Results of taste panel showed that the optimum conditions for broccoli and cauliflower samples were blanching in boiled water for 6 min, steaming for 12 min and microwaving for 4 min according to Mansour *et al.* [11] which was carried out on the same vegetables broccoli and cauliflower.

The proximate chemical composition of fresh and processed broccoli and cauliflower are shown in Table 1. Broccoli had a lower moisture and higher dry matter content compared with cauliflower, Meanwhile, the crude protein, crude fat, crude fiber, and ash of broccoli were higher than those of cauliflower, but cauliflower had higher content of carbohydrate than broccoli. The data in Table 1 showed also that all processing method used (blanching in boiled water, steaming and microwaving) caused a significant increase in moisture content of broccoli and cauliflower, this increasing might be due to leaching of water soluble nutrients during boiling process, since the most increment in moisture content and the lowest dry matter content was observed for microwaved broccoli and broccoli blanched in boiled water. Blanching in boiled water, steaming and microwaving of broccoli and cauliflower caused a significant reduction in crude

protein and crude fat. The lowest reduction was observed for the steamed broccoli and cauliflower (on wet weight basis), since crude protein was 3.34%, 2.65% and crude fat was 0.31%, 0.25% in fresh broccoli and cauliflower, respectively, then crude protein became 2.68%, 1.8% and crude fat reached 0.24%, 0.16% for steamed broccoli and cauliflower, respectively. Ahmed and Ali [6], Rickman *et al*. [12] and Yuan *et al.* [13] concluded the same results, they reported that, the reduction in protein content was related to the protein denaturation at high temperature during blanching processes. It is possible that soluble protein were lost by leaching to the surrounding water. According to USDA [14] every 88 g of raw broccoli contained 2.48 g of protein. However the reduction in crude protein was non significant as a result of the three domestic processing methods in both of broccoli and cauliflower when it calculated on dry weight basis. Similarly, the ash content of all studied samples, was reduced significantly as a result of blanching in boiled water, steaming and microwaving processes. Ash content was 0.92%, 0.80% on wet basis and 9.17% and 8.19% on dry basis for fresh broccoli and cauliflower, respectively and became 0.55%, 8.21% for the broccoli blanched in boiled water (on wet and dry basis) respectively, also for the cauliflower blanched in boiled water ash was 0.45% on wet basis and 7.52% on dry basis. As for the crude fiber content (on dry weight basis), no significant difference was observed for the crude fiber between the fresh and the treated broccoli and cauliflower when calculated on dry basis, while a significant difference was noted between the fresh and the treated broccoli and cauliflower when calculated on wet basis. In regarded to carbohydrate content of broccoli and cauliflower it was reduced significantly as a result of blanching in boiled water, steaming and microwaving the samples calculated on wet basis. The lowest carbohydrate content (on wet basis) was observed in the broccoli and cauliflower blanched in boiled water.

Table 1. Chemical composition of fresh and processed broccoli and cauliflower on wet and dry weight basis

Treatments	Moisture (%)	Dry matter (%)	Crude protein %		Crude fat%		Ash %	
			D	W	D	W	D	W
Fresh broccoli	89.86^{c}±0.26	10.14^{a}±0.04	3.34^{a}±0.10	33.03^{a}±1.0	0.31^{a}±0.01	3.14^{a}±0.13	0.92^{a}±0.01	9.17^{a}±0.09
Water boiled broccoli	93.26^{a}±0.24	6.74^{c} ±0.05	2.27^{c}±0.04	33.82^{a}±0.59	0.18^{c}±0.01	2.77^{b}±0.04	0.55^{c}±0.04	8.21^{c}±0.02
Steamed broccoli	91.87^{b}±0.22	8.13^{b}±0.04	2.68^{b}±0.02	33.06^{a}±0.25	0.24^{b}±0.01	3.04^{a}±0.08	0.71^{b}±0.05	8.82^{b}±0.02
Microwaved broccoli	93.27^{a}±0.16	6.73^{c} ±0.07	2.26^{c}±0.02	33.63^{a}±0.22	0.18^{c}±0.01	2.81^{b}±0.06	0.55^{c}±0.01	8.31^{c}±0.18
Fresh cauliflower	90.30^{b}±0.54	9.83^{a}±0.03	2.65^{a}±0.03	27.03^{a}±0.03	0.25^{a}±0.01	2.61^{a}±0.09	0.80^{a}±0.01	8.19^{a}±0.13
Water boiled cauliflower	93.97^{a}±0.10	6.03^{d}±0.03	1.63^{d}±0.01	27.11^{a}±1.61	0.12^{c}±0.01	2.10^{b}±0.12	0.45^{d}±0.02	7.52^{c}±0.03
Steamed cauliflower	93.30^{a}±0.21	6.71^{b}±0.07	1.80^{b}±0.01	27.01^{a}±0.15	0.16^{b}±0.03	2.54^{a}±0.04	0.53^{b}±0.03	7.91^{b}±0.01
Microwaved cauliflower	93.52^{a}±0.09	6.48^{c}±0.06	1.75^{c}±0.03	27.10^{a}±0.5	0.13^{c}±0.02	2.13^{b}±0.24	0.49^{c}±0.01	7.60^{c}±0.05
Treatments	**Moisture (%)**	**Dry matter (%)**	**Crude fibers %**		**Carbohydrates %**			
			D	W	D	W		
Fresh broccoli	89.86^{c}±0.26	10.14^{a}±0.04	1.14^{a}±0.02	11.26^{a}±0.24	4.43^{a}±0.02	43.40^{a}±0.40		
Water boiled broccoli	93.26^{a}±0.24	6.74^{c} ±0.05	0.76^{c}±0.02	11.29^{a}±0.23	2.98^{c}±0.05	43.91^{a}±0.02		
Steamed broccoli	91.87^{b}±0.22	8.13^{b}±0.04	0.91^{b}±0.01	11.22^{a}±0.25	3.59^{b}±0.04	43.86^{a}±0.03		
Microwaved broccoli	93.27^{a}±0.16	6.73^{c} ±0.07	0.75^{d}±0.01	11.20^{a}±0.25	2.99^{c}±0.05	44.05^{a}±0.50		
Fresh cauliflower	90.30^{b}±0.54	9.83^{a}±0.03	1.05^{a}±0.05	10.77^{a}±0.25	4.95^{a}±0.05	51.40^{a}±0.02		
Water boiled cauliflower	93.97^{a}±0.10	6.03^{d}±0.03	0.64^{d}±0.0	10.67^{a}±0.10	3.19^{c}±0.02	52.60^{a}±0.07		
Steamed cauliflower	93.30^{a}±0.21	6.71^{b}±0.07	0.72^{b}±0.02	10.75^{a}±0.12	3.49^{b}±0.02	51.79^{a}±0.07		
Microwaved cauliflower	93.52^{a}±0.09	6.48^{c}±0.06	0.69^{c}±0.03	10.73^{a}±0.12	3.42^{b}±0.02	52.44^{a}±0.07		

Means followed by the same letter in column are not significantly different at ($p \leq 0.05$)
W: % On wet weight basis
D: % On dry weight basis.

3.2. Minerals Composition:-

Minerals are important for vital body functions such as acid base and water balance. Also, Ca and Mg nutrition in human are important concerns because of the critical role that both Ca and Mg play in bone development and structure as well as cellular metabolism [15,16].

Minerals content (Zn, Fe, Ca, Mg, K and Na) of broccoli and cauliflower are shown in Table 2. It is obvious as seen from the table that broccoli contain higher amount of Zn, Mg, K and Na than that of the cauliflower either than wet or dry weight basis.

As for the minerals content calculated on wet and dry weight basis, it is shown that cauliflower had higher content of Fe and Ca than broccoli. Fresh broccoli contain Zn, Fe, Ca at concentration of 8.67, 2.66 and 112.52 mg/100g on dry weight, respectively, and also fresh broccoli contain Mg, K, Na content of 562.22, 3992.4 and 576.52 mg/100g sample on dry weight, respectively. These results are in agreement with Hanif *et al*. [3], Farnham *et al*. [4], and Acikgoz [17] who stated that broccoli is a good alternative source of Ca, K and Na.

Fresh cauliflower contained 1.26, 3.05, 191.85, 260.42, 3954.93 and 428.28 mg/100g of sample on dry weight of Zn, Fe, Ca, Mg, K and Na, respectively. It was observed also that the different domestic processing methods which were used in treating the broccoli affected the minerals contents significantly. Since the Zn, Fe, Ca, Mg, K and Na contents were higher in fresh broccoli comparing with the other processing methods (blanching in boiled water,

steaming and microwaving). Moreover, it was obvious that steaming the broccoli caused the least significant reduction of Zn, Fe and Ca in comparison with blanching in boiled water and microwaving. The same trend was observed for the Mg, K, Na. Similarly, it was observed that all the processing methods used (blanching in boiled water, steaming and microwaving) significantly reduced the mineral content. In regarded to cauliflower, similarly the three domestic methods affected significantly the minerals content either calculated on wet or on dry basis. Steamed cauliflower had the highest content of all the estimated minerals, while the blanched in boiled water samples had the least amount of the minerals being 0.97 mg/100g for Zn, 2.14mg/100g for Fe and 85.81, 172.97, 3048.42 and 243.78 mg / 100g for Ca, Mg, K and Na (on dry weight basis), respectively. Hanif *et al.* [3] found that K, Ca, Mg and Na were relatively in a good concentration in cauliflower. The steamed cauliflower had the highest amount of all the estimated minerals comparing with that of the blanched in boiled water and microwaved cauliflower**.** Ahmed and Ali [6] stated that microwaved cauliflower contain relatively higher amount of K, Na, Ca and Mg than that of the water boiled samples. Generally both of cauliflower and broccoli can be considered as a good source of minerals.

Table 2. Minerals content of broccoli and cauliflower (mg/100g) on wet and dry weight basis

Treatments	Zn (mg/100g)		Fe (mg/100g)		Ca (mg/100g)	
	W	D	W	D	W	D
Fresh broccoli	0.87^{a}±0.07	8.67^{a} ±0.07	0.26^{a}±0.06	2.66^{a} ±0.03	11.40^{a}±0.10	112.52^{a}±0.04
Water boiled broccoli	0.53^{d}±0.03	8.01^{d} ±0.01	0.11^{c}±0.02	1.68^{d} ±0.05	1.92^{d}±0.02	28.52^{d} ±0.04
Steamed broccoli	0.65^{b}±0.05	8.11^{c} ±0.04	0.18^{b}±0.02	2.33^{b} ±0.03	7.65^{b}±0.05	94.21^{b} ±0.03
Microwaved broccoli	0.57^{c}±0.07	8.61^{b} ±0.05	0.11^{c}±0.01	1.78^{c} ±0.03	4.29^{c}±0.02	63.79^{c} ±0.06
Fresh cauliflower	0.12^{a}±0.02	1.26^{a} ±0.06	0.29^{a}±0.04	3.05^{a} ±0.05	18.83^{a}±0.03	191.85^{a}±0.05
Water boiled cauliflower	0.05^{d}±0.01	0.97^{c} ±0.02	0.12^{c}±0.02	2.14^{c} ±0.04	5.18^{d}±0.03	85.81^{d} ±0.18
Steamed cauliflower	0.07^{b}±0.02	1.14^{b} ±0.04	0.18^{b}±0.03	2.83^{b} ±0.03	11.73^{b}±0.03	175.22^{b} ±0.04
Microwaved cauliflower	0.06^{c}±0.02	0.98^{c}±0.02	0.13^{c}±0.03	2.16^{c} ±0.06	8.23^{c}±0.03	127.03^{c} ±0.03
Treatments	**Mg (mg/100g)**		**K (mg/100g)**		**Na (mg/100g)**	
	W	D	W	D	W	D
Fresh broccoli	57.0^{a}±0.10	562.22^{a}±0.04	404.82^{a}±0.10	3992.4^{a} ±0.05	58.45^{a}±0.05	576.52^{a} ±0.03
Water boiled broccoli	18.55^{c}±0.05	275.37^{c}±0.06	198.40^{c}±0.20	2943.76^{c}±0.17	15.86^{d}±0.06	235.45^{d} ±0.05
Steamed broccoli	36.39^{b}±0.09	447.72^{b}±0.03	308.63^{b}±0.10	3796.3^{b} ±0.10	30.85^{b}±0.05	379.58^{b} ±0.08
Microwaved broccoli	13.80^{d}±0.10	205.20^{d}±0.10	165.55^{d}±0.10	2460.02^{d} ±0.02	17.26^{c}±0.06	256.61^{c} ±0.04
Fresh cauliflower	25.59^{a}±0.09	260.42^{a} ±0.04	388.76^{a}±0.10	3954.93^{a} ±0.03	42.09^{a}±0.09	428.28^{a} ±0.07
Water boiled cauliflower	10.42^{c}±0.02	172.96^{c} ±0.03	183.81^{c}±0.10	3048.42^{c} ±0.04	14.69^{d}±0.09	243.78^{d} ±0.08
Steamed cauliflower	14.48^{b}±0.08	216.26^{b} ±0.05	221.66^{b}±0.06	3308.5^{b} ±0.01	23.47^{b}±0.07	350.44^{b} ±0.04
Microwaved cauliflower	9.90^{d}±0.10	152.83^{d} ±0.03	150.14^{d}±0.04	2317.12^{d} ±0.04	17.01^{c}±0.01	262.50^{c} ±0.05

Means followed by the same letter in column are not significantly different at ($p \leq 0.05$)
W : On wet weight basis
D : On dry weight basis.

3.3. Color Change

Color values of broccoli and cauliflower as measured using hunter lab method are shown in Table 3. Lightness (L value) of broccoli is lower than that of cauliflower; also the broccoli tends to be green to blue in color while cauliflower tends to be yellow in color. The purity of broccoli is higher than that of cauliflower. L value (lightness), showed a significant decreasing as a result of blanching in boiled water, steaming and microwaving the broccoli, a and b values changed significantly after blanching in boiled water, steaming and microwaving process. Martin and Sliva [18] found that broccoli color is the characteristics with most influence on consumer choice. Chlorophyll pigments are responsible for the green color of many vegetables, especially broccoli.

Hue values as shown in Table 3 means that the color of all the samples was in the green area, broccoli blanched in boiled water and microwaved broccoli had hue values of -0.56, -0.56 which mean that the color tends to be green to blue. Fresh broccoli was higher in purity comparing with that of the blanched in boiled water, steamed and microwaved broccoli. The lowest purity value was noticed for the microwaved broccoli, being 7.67. An identical behavior was also reported by Martin and Sliva [18] and Goncalves *et al.* [19].

The data in present study demonstrated that the steamed cauliflower had the highest L values (lightness) being 60.03, while the lowest L value was noticed for microwaved sample being 57.30, a and b values indicated generally that the color tend to be yellow. This change in lightness value (L) may be result from the effect of the heat treatments used in the three domestic processing methods on the cauliflower pigments. Microwaved samples had color (hue value) more yellowish green than the other samples. Generally, the processing methods (blanching in boiled water, steaming and microwaving) changed significantly a, b values.

The purity of cauliflower color changed significantly as a result of blanching in boiled water, steaming and microwaving of cauliflower. The purity of the color was the highest for fresh cauliflower (9.47), followed by that

of the cauliflower blanched in boiled water (9.21) and the microwaved cauliflower (9.07), and the lowest purity value was noticed for the steamed cauliflower being 8.30. Pellegrini *et al.* [20] studied the effect of heat treatments on cauliflower color, and they found that the L values were the highest for raw followed by microwaved and then the boiled cauliflower, while the highest hue value was for the boiled samples.

Table 3. Effect of domestic processing methods on color of broccoli and cauliflower by Hunter lab ultra scan VIS

Method of processing	L	a	b	Hue	Purity
Fresh broccoli	51.57^{a}±0.10	-5.76^{c}±0.06	14.89^{a}±0.11	-0.38^{b}±0.04	13.73^{a}±0.10
Water boiled broccoli	38.46^{b}±0.06	-6.57^{d}±0.06	11.70^{b}±0.10	-0.56^{c}±0.06	9.68^{c}±0.08
Steamed broccoli	37.64^{c}±0.14	-2.47^{a}±0.07	10.31^{c}±0.10	-0.23^{a}±0.03	10.00^{b}±0.20
microwaved Broccoli	33.55^{d}±0.15	-5.20^{b}±0.10	9.27^{d}±0.07	-0.56^{c}±0.06	7.67^{d}±0.07
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Fresh cauliflower	58.03^{c}±0.03	-1.07^{a}±0.02	9.54^{a}±0.05	-0.11^{a}±0.02	9.47^{a}±0.06
Water boiled cauliflower	59.75^{b}±0.15	-2.19^{d}±0.04	9.47^{b}±0.07	-0.23^{d}±0.03	9.21^{b}±0.05
Steamed cauliflower	60.03^{a}±0.03	-1.85^{c}±0.05	8.51^{d}±0.11	-0.21^{c}±0.02	8.30^{d}±0.10
microwaved cauliflower	57.30^{d}±0.10	-1.68^{b}±0.04	9.23^{c}±0.03	-0.18^{b}±0.02	9.07^{c}±0.05

Means followed by the same letter in column are not significantly different at ($p \leq 0.05$).

3.4. Organoleptic Properties:-

Sensory properties of broccoli and cauliflower are shown in Table 4, generally, the data confirmed a high acceptability for raw and processed broccoli and cauliflower as judged by the panelists. Sensory properties of broccoli and cauliflower were affected by processing (blanching in boiled water, steaming and microwaving). The color and taste values were affected significantly by processing method. Fresh broccoli and cauliflower had the highest color value (8.9). On the other hand the steamed broccoli had the highest odor, texture and over all acceptability values being 8.40, 8.35 and 8.8, respectively. Appositively the microwaved broccoli was the least preferable in odor and texture among the other processed broccoli. Greve *et al*. [21] and Heaton and Marangoni [22] reported that the heat applied to green vegetables during water blanching, degrades chlorophyll pigments, resulting in a change of greenness color and produced structural deformation on vegetal tissues, promoting a gradual decrease of product texture Also, Goncalves *et al*. [23] stated that the panelist's evaluation indicated that broccoli suffered a notable loss of green color and their firmness decreased.

The color, odor and texture value of cauliflower were decreased significantly by processing. The cauliflower blanched in boiled water had significantly the lowest color, odor and texture values being 6.80, 7.30 and 6.65 respectively, while the microwaved cauliflower had the highest color, odor and texture values being 8.70, 8.35 and 8.35 among the processed samples respectively. The change in taste was significant, similarly the cauliflower blanched in boiled water had the lowest taste (7.30), while microwaved cauliflower had the highest value of taste being 8.20. These results are in accordance with these of Renumarn *et al*. [24] who reported that the heat treatments affected remarkably the color and odor of vegetables.

Generally it can be concluded that there was no significant difference between microwaved and steamed broccoli and cauliflower in color, taste, texture values, while blanched in boiled water one had significantly the least value in regard to over all acceptability of cauliflower.

Table 4. Organoleptic properties of broccoli and cauliflower as affected by different domestic processing methods

Method of processing	Color	Taste	Odor	Texture	Over all acceptability
Fresh broccoli	8.90^{a}±0.56	5.00^{b}±1.05	8.60^{a}±0.69	8.70^{a}±0.67	8.40^{ab}±0.84
Broccoli boiled for 6 min	7.90^{b}±0.31	7.80^{a}±1.13	7.70^{ab}±1.15	8.35^{a}±1.10	8.00^{b}±0.94
Broccoli steamed for 12 min	8.10^{b}±0.31	8.30^{a}±0.67	8.40^{ab}±0.96	8.35^{a}±1.29	8.80^{a}±0.42
Broccoli microwaved for 4 min	8.00^{b}±0.81	7.80^{a}±1.13	7.35^{b}±0.88	7.65^{a}±1.15	7.95^{b}±0.76
Fresh cauliflower	8.90^{a}±0.73	5.10^{b}±1.28	8.70^{a}±0.94	8.80^{a}±0.63	8.60^{a}±0.96
Cauliflower boiled for 6 min	6.80^{b}±1.68	7.30^{a}±2.16	7.30^{b}±1.70	6.65^{b}±2.08	7.10^{b}±0.79
Cauliflower steamed for 12 min	8.35^{a}±1.10	8.10^{a}±0.99	8.15^{ab}±0.94	8.30^{a}±0.85	8.25^{a}±0.71
Cauliflower microwaved for 4 min	8.70^{a}±0.67	8.20^{a}±0.91	8.35^{ab}±0.74	8.35^{a}±0.57	8.40^{a}±0.56

Means followed by the same letter in column are not significantly different at ($p \leq 0.05$).

4. Conclusion

In the light of data, it could be concluded that, broccoli and cauliflower had a noticeable amount of basic nutrients such crude protein, crude fiber and carbohydrates and also noticeable amount of ash and crude fat. Also, they considered as rich source of minerals (Zn, Fe, Ca, Mg, K, and Na), among the studied processing method steaming had lowest reduction in most of studied nutrients**.** The domestic processed broccoli and cauliflower were accepted when evaluated by taste panel testing. From these results it can be concluded that using steaming method both of broccoli and cauliflower is the most healthy and preferable method.

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