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Capsaicin Content and Quality Characteristics in Different Local Pepper Varieties (Capsicum Annum) and Acid-Brine Pasteurized Puree

Hesham A. Eissa, B.E. Mostafa and A.S. Hussein
Department of Food Technology, National Research Centre, Cairo, Egypt

Abstract: The study material consisted of fresh pepper from 5 different varieties and 50 processed pasteurized purees samples. Each variety was distributed equally into 10 parts and each part was subjected to 1 of 10 different treatments. Pasteurized puree was completed by brining either in water (control) or in diluted concentrations of acetic acid, citric acid or sodium metabisulphite at a pepper: Acid ratio of 60: 40 (w v^{-1}). All samples were analyzed chemically for the contents of capsaicin and chlorophyll. The final quality of each product was determined by the extractable color by the American Spice Trade Association (ASTA), Hunter lab color and the tint. All samples were subjected to complete sensory evaluation based on scoring for preferences of color; appearance; odour, taste and pungency. Capsaicin was highest in the fresh hot green (226.2 mg $100g^{-1}$) and red colored (175.7 mg $100g^{-1}$) compared with the respective figures obtained with the sweet peppers. The superior level of capsaicin in the hot pepper varieties was maintained after acid-brining in the pasteurized purees. Brining in the presence of acetic acid (0.25-0.7 %) resulted in the highest scoring compared with the respective scores obtained with the other treatments.

Key words: Green, yellow and red pepper, puree, acid-brine, color, pasteurization, polyphenoloxidase, peroxidase, capsaicin, ASTA, tint and sensory evaluations

INTRODUCTION

Sweet and hot peppers (*Capsicum annum*) are important vegetables and condiment crops grown in the tropical and subtropical regions of the world and vary widely in size, shape, color, flavour and sensory heat. The change in pepper color from greentook place at the surface as a result of chlorophyll degradation under the action of temperature and illumination with concomitant increase in its carotenoid content. Carotenoids in the edible portions of pepper can provide health benefits to humans (Ricardo and Jose, 1996; Russo and Howard, 2002). The green and the red peppers are consumed fresh, canned or dried as powdered food additives.

The level of pungency of the capsicum species depends upon the concentration of capsainoids; primarily capsaicin in the pepper fruit. Capsaicin isolated from pepper is an off-white crystalline compound; insoluble in water and freely soluble in ethyl alcohol and chemically it belongs to the methyl-vanillyl none amide class (Bernal *et al*., 1993). The concentration of capsaicin varies according to the variety of pepper; the geographical origin and the climatic conditions. Capsaicin causes inflammation of the mucous membranes (Suzuki and Iwai, 1984). Green and red peppers are valued for their sensory attributes of color, pungency and aroma and capsaicin content of red pepper is one of the main parameter that determines its commercial quality (Lee and Howard, 1999; Rajput and Parulekar, 1998).

The concentrated peppers form oleoresins, which prove to be economic and convenient, provided that they save space during the transport and the storage. In addition, oleoresins are more stable than the whole or the powdered peppers (Minguez and Hornero, 1994). Oleoresins are characterized by their deep color, sweet odour with or without pungency and the United States is the largest consumer. Also, oleoresins free from pungency are used by the food industry as a coloring agent for processed meats, salad dressings and margarines (Minguez and Hornero, 1993). The pungent rich spicy oleoresins are used largely by the food industry as flavoring and coloring agents for processed meats, snacks, soups, sauces, alcoholic beverages and soft drinks (Reineccius, 1994).

The use of pasteurization is a preservation technology, which can provide fresh-like quality to heat sensitive foods but it enhanced some enzyme activities and changes flavors and color of several other foods (Palou *et al*., 1999). Consequently, for the development of pasteurization process for fruit products, it is essential to understand the influence of pasteurization on (color, total carotenoids, capsaicin content and sensory evaluation) quality characteristics of food products.

Corresponding Author: Hesham A. Eissa, Department of Food Technology, National Research Centre, Cairo, Egypt

Brining and pasteurization are commonly used to preserve fresh peppers and calcium addition to pepper brine has been shown to reduce softening during pasteurization and storage (Howard *et al*., 1994b). Calcium firms plant tissues by forming ionic cross-linkages with polysaccharide polyelectrolytes, especially galacturonans, resulting in a structure that retards both enzymatic (Buescher and Hudson, 1986) and nonenzymatic softening (Howard and Buescher, 1990). Increasing the cohesive properties of the cell wall-middle lamella complex may prevent leaching of phytochemicals out of pepper fruit during pasteurization and storage, resulting in greater antioxidant retention (Lee and Howard, 1999).

The use of Sulphur Dioxide (SO_2) in food processing has been recommended for proper preservation of flavour and color as well as enhancing the shelf life of dried fruits and vegetables. Pepper samples treated with So_2 showed better retention of color than the untreated control samples, indicating that treating green peppers with sodium meta-bisulphite solutions prior to processing had superior color retention (Rajput and Parulekar, 1998; Sigge *et al*., 2001). The application of citric acid was reported to control of the browning of Litchi fruit (Jiang and Fu, 1998). Using a mixture of ascorbic acid, citric acid and calcium chloride successfully protected sliced apples from browning (Pizzocaro *et al*., 1993).

Phytochemical processing is affected by environmental factors such as pH, oxygen, light, temperature and the presence of other phytochemicals. Pasteurization of jalapeno cultivars resulted in nutrients which may be lost via physical leaching into the brine solution during processing and storage (Howard *et al*., 1994b; Price *et al*., 1997).

The objective of the research was to measure the capsaicin content in the fruits of fresh sweet and hot green, yellow and red peppers. The effect of pasteurization with different acid-brine treatments on the quality characteristics and sensory evaluation was studied as well.

MATERIALS AND METHODS

Fresh hot and sweet "banana or bell" green, yellow and red peppers (Capsicum annum L., cv. Golden Summer) were obtained from a local supermarket in Cairo, Egypt. The fruit peppers were kept in cold storage at 10°C for 2 days prior to being processed. All fruit peppers were washed, trimmed, the cores discarded and the seeds and interlobular material removed. Blemishes and area with color variation were also removed and discarded. After being halved, the peppers were diced with a knife and were drained in a sieve to remove any excess fluid. Chemical analyses were conducted on fresh peppers.

Acid-brine pasteurization for the processing of pepper puree (Experimental design): The peppers after being halved were packed at a rate of ten fruits per glass jars to obtain a pack out ratio of 60% pepper and 40% acid-brine (w v^{-1}). Acid-brine treatments provided 4% NaCl and 0.08% $CaCl_2$ and one of the following different acids concentrations as follows: 0.25, 0.50 and 0.7% Acetic Acid (AA); 0.1, 0.50 and 1% Citric Acid (CA) and 0.01, 0.03 and 0.05% sodium meta-bisulphite (So_2) in the final product. Peppers were pasteurized to an internal temperature of 74°C, held for 10 min, cooled with tap water. Then, all untreated and acid-brine pasteurized pepper samples blended for 30 seconds and concentrated by heating at 74°C to TSS (16 °Brix) as a puree then cooled with tap water and stored in closed glass jars at 4°C for 8 weeks. Control pasteurized (in water only) pepper puree was also prepared in the same way without using acid-brine solution and served as control. Three replicates were prepared for each treatment.

Analytical methods

- Moisture content was determined gravimetrically according to the A.O.A.C. (2000) method.
- The percent Total Soluble Solids (TSS), expressed as °Brix (0-32), was determined with a Hand refractometer (ATAGO, Japan) according to the method reported by Tung-Sung *et al*. (1995).
- Capsaicin determination:

Capsaicin determination was following the method of Anan *et al*., (1996). The chopped samples were extracted with diethyl ether at a ratio of 1:10 (w v^{-1}). Aliquots were taken for the color reaction using the Folin-Ciocalteu reagent. The tubes were allowed to stand at room temperature for 1 h and the developed blue colour was measured colorimetrically at 760 nm. Capsaicin standard (Sigma, 98%) was dissolved in diethyl ether with serial dilutions to bring the final concentrations to 10, 30, 50, 100, 200 and 400 mg L^{-1}.

Assay of the activities of Peroxidase (POD) and Polyphenoloxidase (PPO): Peroxidase (POD) and Polyphenoloxidase (PPO) Weighed portions (10 g) were homogenized in 100 mL 0.2 mM sod. phosphate buffer pH 7 in a laboratory blender. The homogenates was centrifuged at 5000 rpm at 4°C for 10 min. The supernatant was aspirated and saved on ice for the enzymatic assays (Sung and Song, 2003). A 4054 UV/ Visible spectrophotometer, LKB-Biochrom was used throughout the course of the study.

Peroxidase enzyme activity (POD) assay: The reaction mixture contained 50 mM potassium phosphate (pH 6•8), 10 mM hydrogen peroxide, 9 mM guaiacol and enzyme extract in a total volume of 3 mL, as described (Olmos *et al.*,1997). The kinetic changes in the absorbance at 470 nm were recorded every 30 sec for 3min and the linear range of the curve was plotted Peroxidase units is defined as the amount of pepper extract that gives 0.1 abs at 25°C in 3 mL reaction mixture.

Polyphenoloxidase (PPO) assay 2 mL catechol 0.1M was used as a substrate. The reaction was initiated by adding 1 mL of the pepper supernatant and the assay was carried out at 25°C.The kinetic rate of oxidation was monitored spectrophotometrically by recording the changes in absorbance at 420 nm at 30 sec intervals for the first 5 min. The linear range of the kinetic reaction was plotted. Polyphenoloxidase (PPO) unit was defined as an increase in 0.1 absorbance unit per minute at 420 nm (Sun and Song, 2003).

Chemical color determination: The ASTA units and the tint of the different varieties (Table 3), as determined from the paprika obtained from the fruit of the last harvest (dried and milled fruits), are indicative of the quality reached in each variety at the end of the ripening process, since they show the total pigment concentration synthesized in the fruit and the relation between the red and yellow carotenoids. In this sense, varieties in the last ripening phase (red fruits).

ASTA color values: Evaluation of the Extractable Color by the American Spice Trade Association (ASTA). A weighed portion of 0.07-0.11 g of paprika was put into a tared 100 mL flask. Acetone was added to the mark, the mixture was stirred and after 4 h, an aliquot of the transparent decanted extract was taken. The absorbance of the solution at 460 nm was measured. Units of color were calculated from ASTA (1985).

ASTA units = absorption of extract * 16.4 * *If* g^{-1} of sample: In which *If* is a correction factor for the apparatus, calculated from the absorbance of a standard solution of potassium dichromate and ammonium and cobalt sulfate. The total pigment content was determined using an LKB UV-Visible 4054 spectrophotometer.

Tint determination: To evaluate the tint, or quotient of the absorbances between the red and yellow carotenoid pigments of each variety, the absorption spectra of the extracts of each variety in acetone were registered in the visible zone (380-600 nm). This quality criterion is specifically quantified by the following quotient: *T*) absorbance at 470 nm/absorbance at 455 nm (Ricardo and Jose, 1996). The tint value was calculated from only one sample per variety, obtained by mixing the same quantity of paprika for each of the repetitions.

Color determinations: Hunter a*, b* and L* parameters were measured with a color difference meter using a spectro-colorimeter (Tristimulus Color Machine) with the CIE lab color scale (Hunter, Lab Scan XE-Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Color Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) (Sapers and Douglas, 1987).

The Hue (H)*, Chroma (C)* and Browning Index (BI) were calculated according to the method of Palou *et al.* (1999) as follows:

$$H^* = \tan^{-1} [b^*/a^*] \qquad (1)$$

$$C^* = \text{square root of } [a^{2*} + b^{2*}] \qquad (2)$$

$$BI = [100 (x-0.31)]\ 10.72 \qquad (3)$$

Where:-

$$X = (a^* + 1.75L^*) / (5.645L^* + a^* - 3.012b^*)$$

Sensory evaluation: A panelist consisting of 12 members evaluated studied untreated and acid-brine pasteurized pepper puree samples according to a well established standard method (Cavella *et al.*, 2000; Sigge *et al.*, 2001). Color, odor, taste, pungency and appearance of the sweet and hot concentrated green, yellow and red pepper samples were subjectively determined by panelists using a ten point scale, where (10 = excellent and 1 = bad), as described by The untreated and acid-brine pasteurized pepper puree samples stored for 4 weeks at 4°C and analyzed sensory evaluation.

Statistical analysis: For each treatment and sample, three replicates were used. The mean values as well as the standard deviation of the three replicates of each sample were computed.

The results of sensory evaluation were analyzed statistically using the Analysis of Variance (ANOVA with 2 ways). The Least Significant Difference (LSD) as described by Richard and Gouri (1987).

RESULTS AND DISCUSSION

Physical and chemical characteristics of fresh pepper: The moisture content in the fresh pepper averaged 90.1;

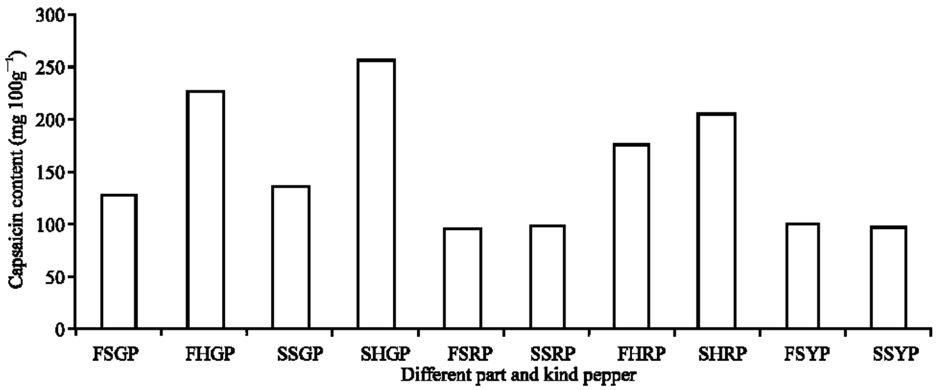

Fig. 1: Capsaicin content (mg $100g^{-1}$) in different part and kind of fresh pepper

Table 1: Physical and chemical characteristics of fresh and flesh of sweet and hot of green, yellow and red pepper fruit

Physical and chemical characteristics	Fresh Sweet Green Pepper (FSGP)	Fresh Sweet Red Pepper (FSRP)	Fresh Sweet Yellow Pepper (FSYP)	Fresh Hot Green Pepper (FHGP)	Fresh Hot RedPepper (FHRP)
Moisture content (%)	90.1	89.9	88.0	90.0	89.0
TSS (°Brix)	8.0	8.0	9.0	9.0	11.0
Capsaicin content (mg $100g^{-1}$)	127.50	96.0	100.41	226.2	175.73
ASTA value (unit)	1.68	3.75	3.44	3.14	3.32
Tint value (unit)	0.96	1.35	1.47	2.04	2.14
PPO activity (unit g^{-1})	1.31×10^{-3}	9.44×10^{-4}	1.018×10^{-3}	1.119×10^{-3}	7.63×10^{-4}
POD activity (unit g^{-1})	4.93×10^{-4}	5.8×10^{-4}	4.29×10^{-4}	3.95×10^{-4}	3.96×10^{-4}
Hunter L-value	38.74	28.02	64.25	37.99	21.06
Hunter a-value	-10.49	35.39	21.36	-10.90	13.46
Hunter b-value	25.59	19.62	68.35	28.65	7.45

89.9; 88.0; 90.0 and 89.0 for the fresh sweet green, red, yellow, hot green and hot red peppers, respectively (Table 1). TSS content was 8°Brix in sweet red and green pepper, 9°Brix in sweet yellow and hot green pepper and 11°Brix in hot red pepper fruit.

The capsaicin content was highest in the hot pepper varieties with mean levels of 226.2 mg $100g^{-1}$ in the green and 175.7 mg $100g^{-1}$ in the red varieties. The lowest mean level of 96 mg $100g^{-1}$ was found in the sweet red pepper variety (Table 1).

The present findings agree with those reported earlier showing that the amount of capsaicin content in green hot peppers was higher than in the red ripe ones (Rajput and Parulekar, 1998). Lee and Howard (1999) reported that the fruits of a nonpungent cultivar of *Capsicum annuum* L., named CH-19 Sweet,contains only a small amount of capsaicinoids but has considerable Capsaicinoid-Like Substances (CLSs); with no pungency upon oral tasting The capsaicin content in the different parts of the pepper is presented in Fig. 1. In general, the capsaicin content in flesh or placenta of pepper fruit was higher than in seed of green, yellow and red pepper fruit. Highest level was found in the seeds and placenta of the hot red pepper. Whereas, flesh and seeds of sweet yellow pepper could not be considered as a source of capsaicin content (Fig. 1). However, the amount of capsaicin content in all parts and kind of peppers was in the range of 96.03-256.17 mg $100g^{-1}$. Results indicated that the capsaicin content in green hot pepper fruit was higher than in red hot pepper fruit. This result confirmed with the results of Rajput and Parulekar (1998) who reported that the amount of capsaicin varies from 160-210 mg $100g^{-1}$ in green hot peppers, whereas the red ripe fruits contain around 113-160 mg $100g^{-1}$. The variation in the composition of fruits depends on the stage of maturity. Also, they found that the pungency is due to an active principle known as capsaicin or capsicutin mainly present in the pericarp and placenta of the fruit. The heat of the pepper is present in the pepper's seeds and in the membrane (placenta) to which they are attached inside the pepper. The seed and placenta of green and red pepper fruit are among the hottest of all. The removal of the seeds and membrane can greatly reduce the heat of a jalapeno pepper. However, The flesh of some peppers is so hot that they are not palatable even after the removal of the seed/membrane.

ASTA units are the extractable color in pepper, which correspond to total carotenoid content. The ASTA units show the total pigment concentration synthesized in the fruit and the relation between the red and yellow carotenoids (Lee *et al*., 2004). In the present study, the lowest ASTA units were found in the sweet green pepper variety (1.68 unit on a dry basis). The differences

Table 2: Effect of acid-brine pasteurization process on Pungency (Capsaicin content, mg $100g^{-1}$) of all maturation of pepper puree

Treatments	SGPP	SRPP	SYPP	HGPP	HRPP
Control	306.63	165.01	153.31	626.91	464.58
AA 0.25%	307.36	206.70	113.10	678.83	503.33
AA 0.50%	316.13	222.05	135.76	723.44	509.91
AA 0.70%	325.64	271.78	176.71	760.00	515.76
CA 0.10%	298.58	213.28	136.49	793.64	464.58
CA 0.50%	305.16	241.06	149.66	795.10	482.13
CA 1.00%	309.55	243.99	164.28	812.65	497.48
So_2 0.01%	316.13	219.13	158.43	762.93	523.08
So_2 0.03%	329.30	232.29	182.56	762.12	523.81
So_2 0.05%	240.99	269.58	197.19	853.60	531.85

fluctuated between narrow ranges (3 .1-3.7 unit on a dry basis) among the other different varieties of pepper fruits. The tint values fluctuated 'between' 0.964 to 2.137 in the different varieties of pepper fruits.

Total yellow pigment content was higher than total red pigment content in the all kind of pepper tested Pigment contents in green, yellow and red pepper would also result in a shift in a* from negative (green pepper) to positive (redness pepper). These shifts towards positive a* (red color), would result in part to its very high content of Cryptocapsin (red pigment) which has been shown to have excellent discriminatory, capabilities in monitoring color retention (Sigge *et al.*, 2001). These results are in good agreement with earlier reports with pimento peppers in of the cultivars Shisido and Midori (Hyung *et al.*, 2002).

Low Polyphenoloxidase (PPO) activities were found in the green and yellow pepper varieties compared with the respective activities found in the red varieties pepper fruit (7.63×10^{-4}-9.44×10^{-4}). The mean Peroxidase (POD) activity was less variable (3.95×10^{-4} -5.8×10^{-4}) between the different varieties.

Effect of acid-brine pasteurization process on pungency (capsaicin content) of pepper puree: The mean content of capsaicin of green and red pepper puree following acid-brine pasteurization is presented in Fig. 2. The mean capsaicin level increased following the different acid brine treatment with no variation between treatments.

The green hot pepper puree was highest in its capsaicin content; the capsaicin contents in sweet green, yellow and red pepper puree were lower than in hot of green and red pepper puree (Fig. 2).

Capsaicin contents initially increased after processing and storage (Fig. 2) their retention rates were higher than the respective levels in fresh peppers (Table 1). However, the incorporation of high sodium chloride (4%) for the processing of acid brine puree created an osmotic potential gradient between the brine solution and pepper tissue, resulting in water migration out of the pepper rings. Additionally, some of the capsaicinoid increase may have resulted from liberation of capsaicin from complexed compounds during cooking (Harrison and Harris, 1985). A study reported that the capsaicinoid content in jalapeno peppers increased 19% after cooking for 10 min at 100 °C; whereas in blanching and pasteurization of jalapeno peppers didn't change the capsaicin content (Saldana and Meyer, 1981). The capsaicinoid content of yellow banana pepper was reported to be stable during processing (Lee and Howard, 1999). The brine containing calcium chloride did not affect capsaicin content losses during pasteurized and storage of peppers puree (Table 2). Saldana and Meyer (1981) also reported that capsaicin levels in jalapeno peppers were not influenced by various calcium salt brine solutions after blanching and pasteurization. The characteristics hot sensation known as pungency is caused by capsanoids, which are the major pungent principals of green and red pepper (Lee *et al.*, 2004).

Effect of acid-brine pasteurization process on ASTA and tint content of pepper puree: ASTA and tint values were well retained in all acid-brine pasteurized pepper puree samples (Table 3). Their mean values increased in Pepper puree and acid brine concentration up to 0.7% didn't affect the ASTA units of the resulting puree.

The results of the surface and extractable color of acid-brine pasteurized pepper puree suggest that the yellow carotenoids ASTA values rather than tint values might be more sensitive to high concentration of acid-brine (AA, CA or So_2), as seen in Table 3.

In our study, the large osmotic gradient between the brine solution and pepper fruit promoted leaching of water soluble components, including ASTA and Tint values, out of the fruit. These gains were due to a concentration effect that occurred when fresh peppers were pasteurized in the high-salt brine solution. Because total carotenoids or color were relatively stable and retained well in processed peppers after equilibration with brine solution, it may be beneficial to use peppers maturates that have high total carotenoids contents for processing. Results concluded that quality factors including ASTA (total carotenoids) and Tint values could serve as good indices of general quality in green, yellow and red of sweet and hot pepper puree. The presence of capsaicin had a

Table 3: Effect of acid-brine pasteurization on ASTA, Tint and total carotenoids (mg g^{-1}) values of all maturation of pepper puree

Treatments	Values	SGPP	SRPP	SYPP	HGPP	HRPP
Control	ASTA	2.283	9.520	6.973	4.313	8.928
	Tint	0.288	0.418	0.736	0.370	0.533
Acetic acid 0.25%	ASTA	3.109	10.799	5.642	3.271	7.688
	Tint	0.445	0.457	0.649	0.251	0.544
Acetic acid 0.50%	ASTA	3.483	12.653	5.757	3.493	9.341
	Tint	0.457	0.553	0.649	0.161	0.431
Acetic acid 0.7%	ASTA	5.409	17.343	6.058	3.616	11.342
	Tint	0.635	0.761	0.578	0.137	0.615
Citric acid 0.1%	ASTA	2.519	9.118	5.002	4.133	7.478
	Tint	0.490	0.373	0.477	0.401	0.774
Citric acid 0.5%	ASTA	3.136	11.619	5.884	5.361	9.656
	Tint	0.460	0.492	0.565	0.484	0.608
Citric acid 1%	ASTA	3.802	11.677	8.882	4.510	11.322
	Tint	0.377	0.505	0.724	0.460	0.488
So_2 0.01%	ASTA	2.696	10.168	6.829	3.846	8.594
	Tint	0.602	0.444	0.809	0.388	0.714
So_2 0.03%	ASTA	4.435	10.570	7.416	4.485	9.453
	Tint	0.591	0.447	0.748	0.428	0.716
So_2-0.05%	ASTA	5.274	11.775	7.807	5.010	10.470
	Tint	0.459	0.500	0.758	0.502	0.543

Table 4: Effect of acid-brine pasteurization process on Hunter color values of all maturation of pepper puree

Acid-brine Pasteurizat-ion	SGPP b*	SGPP a*	SGPP L*	SRPP b*	SRPP a*	SRPP L*	SYPP b*	SYPP a*	SYPP L*	HGPP b*	HGPP a*	HGPP L*	HRPP b*	HRPP a*	HRPP L*
Control	35.4	3.84	35.6	51.1	45.2	35.2	84.8	18.6	56.5	27.3	-8.9	28.9	39.8	30.7	26.1
AA 0.25%	38.4	1.06	39.3	50.6	46.8	35.5	85.6	19	57.5	26.9	2.26	32.0	38.5	30.9	25.1
AA 0.50%	36.3	2.15	38.1	50.6	47.6	33.8	83.7	18.8	55.8	26.3	3.22	31.5	39.6	29.9	26.3
AA 0.70%	38.7	-0.3	38.7	59.7	48.8	37.7	85.5	19.6	56.3	28.4	2.75	31.8	39.9	33.3	25.9
CA 0.10%	35.5	1.39	37.3	52.9	46.5	35.1	83.9	19.1	56.9	29.9	-3.3	31.9	40.6	33.9	26.5
CA 0.50%	39.6	-0.4	40.6	54.8	46.6	35.4	81.6	17.9	54.9	31.6	-2.4	32.5	38.5	27.7	25.5
CA 1.00%	38.3	0.66	38.5	54.4	47.0	35.0	84.1	17.5	56.3	28.5	-1.2	30.2	37.3	32.1	24.3
So_2 0.01%	37.2	-1.2	38.3	59.3	45.8	38.9	86.1	16	58	27.5	-3.9	29.3	40.1	31.2	26.7
So_2 0.03%	36.8	0.58	36.9	60.3	48.2	38.4	87.9	21.7	55.9	26.9	-4.2	29.2	39.9	34.3	26.2
So_2 0.05%	38.8	0.48	38.6	59.4	47.2	37.5	87.8	18.6	57.9	27.7	-4.6	30.6	39.4	35.3	25.9

positive effect on deposition of ASTA values (total carotenoids) in pasteurized hot pepper puree and on content of tint units, as seen in Fig. 2 and Table 4. These results were similar to those obtained with that capsaicin had a positive effect on deposition of carotenoids in yolks and on content of retinol equivalents (Gonzalez *et al*., 1999). The ASTA units correlated significantly with the respective tint values. However, $CaCl_2$ treatment did not affect carotenoids or color losses during processing and storage. Pepper puree samples pasteurized with acid-brine in the presence of $CaCl_2$ and $NaCl_2$ had ASTA and tint content greater than untreated pasteurized peppers puree (control) throughout the study. Disruption of cell membranes during pasteurization in salt-acid brines (AA, CA or SO_2) results in loss of turgor pressure, which is an-important factor affecting cell integrity. Supplementation of calcium in brine solution is important because Ca^{2+} binds with pectic substances to create a structure that resists both enzymatic and non-enzymatic softening.

However, calcium ions presumably complexed with cell wall polyuronides, creating a stronger cell wall that resisted expansion and associated absorption of water and solutes (Howard and Buescher, 1990). Calcium chloride in brine solution was reported to maintain the quality of pepper puree compared to non-calcium treated peppers and to prevent acid-catalyzed softening during pasteurization of pepper fruit. These results confirmed with the both results of Saldana and Meyer, (1981) and Howard *et al.* (1994b) in jalapeno pepper rings.

Effect of acid-brine pasteurization process on Hunter color and parameters of pepper puree: The Hunter color values of acid-brine pasteurized pepper puree samples were determined after processing and storage. Changes in L*-values were inversely proportional to the changes in a*-values of the Hunter color.

Depending on the acid-brine (acetic acid, Citric acid or So_2) pasteurization, the points which represent the puree of sweet and hot green pasteurized pepper move from the negative a* values (green component) in low concentration to the positive a* values (red component) in high concentration, as seen in Table 5. The a*-values and BI for citric acid and SO_2-brine pasteurized pepper puree were low, in contrast to high values for untreated and acetic acid-brine pasteurized pepper puree

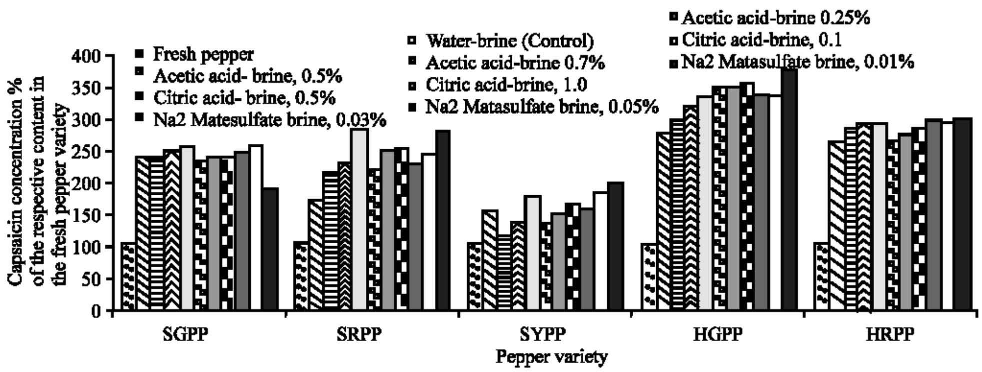

Fig. 2: Histogam illustrating the effect of processing of pepper into acid brine puree on the capsaio capscian level as (%) of the respective content in the fresh variety

Table 5: Effect of acid-brine pasteurization process on color parameters value of all maturation of pepper puree

	SGPP			SRPP			SYPP			HGPP			HRPP		
Treatments	H*	C*	BI	H*	C*	BI	H*	C*	BI	H*	C*	BI	H*	C*	BI
Control	83.81	35.63	390.75	48.47	68.22	936.651	77.63	86.82	1205.93	71.92	28.74	288.26	52.45	50.28	1077.94
AA 0.25%	88.42	38.42	365.72	47.25	68.89	901.89	77.49	87.72	1176.72	85.19	26.98	280.38	51.12	49.39	1086.84
AA 0.50%	86.61	36.39	352.10	46.67	69.43	998.89	77.36	85.74	1196.84	83.02	26.50	282.91	52.85	49.66	1044.09
AA 0.70%	89.51	38.68	378.79	50.73	77.06	1167.90	77.08	87.75	1256.00	84.47	28.54	315.52	50.15	51.94	1083.97
CA 0.10%	87.75	35.49	348.50	48.69	70.44	1026.12	77.17	86.03	1121.63	83.7	30.08	315.97	50.1	52.93	1078.83
CA 0.50%	89.41	39.58	359.40	49.6	71.93	1100.14	77.33	83.52	1150.34	85.67	31.70	347.23	54.31	47.41	1062.06
CA 1.00%	89.01	38.25	376.64	49.16	71.92	1103.68	78.26	85.87	1185.24	87.51	28.49	330.36	49.26	49.25	1079.26
So_2 0.01%	88.17	37.20	352.50	52.22	74.93	1070.71	79.53	88.04	1192.04	81.89	27.77	313.14	52	50.84	1032.26
So_2 0.03%	89.1	36.83	379.89	51.32	77.18	1151.25	76.13	90.60	1432.5	81.21	27.29	300.41	49.24	52.59	1052.22
So_2 0.05%	89.29	38.80	387.17	51.52	75.89	1178.54	78.06	89.75	1253.09	80.53	28.03	286.40	48.24	52.85	1036.52

(Table 5 and 6). The CIE L*, a*, b* color parameters, Hue angle (H*), Chroma (C*) and Browning Index (BI) increased by increasing of acid-brine concentrations (acetic acid, Citric acid or So_2), as seen in Table 5 and 6.

From the above results it could be concluded that the met bisulphites (SO_2) and citric acid -brine pasteurized pepper puree have the best color values and lower non-enzymatic browning compared to the untreated and acetic acid -brine pasteurized pepper puree, as seen in Table 5 and 6. However, it improved the color of pasteurized pepper puree.

Generally, results obtained with the three SO_2 concentrations in the brine pasteurization did not differ significantly, except in the case of the calculated hue angle, where better retention of green color was obtained with the higher SO_2 concentration 0.05% at lower temperatures storage (4°C). Lower SO_2 concentrations can thus be used to obtain acceptable color retention. The results are in accordance with those of Sigge *et al.* (2001) who reported that the lower SO_2 treatment concentrations used to obtain acceptable color retention in green bell pepper. The results are in accordance with those of Recardo and Jose (1996), Sigge *et al.* (2001), Kim *et al.* (2002) and Se-Won-Park *et al.* (2003).

Effect of acid-brine pasteurization process on sensory evaluation of hot and sweet pepper puree

Effect of acid-brine pasteurization process on sensory evaluation of sweet pepper puree: The color of pasteurized food is the first quality attribute used to judge acceptability of pasteurized products. Table 6 represents the statistical analysis and Less Significant Relation (L.S.R.) of color, odor, taste, pungency and appearance of pasteurized pepper with lowest concentration of acid-brine (acetic acid, Citric acid or So_2). It is clear that the pasteurized pepper with acetic acid and SO_2in the brine solution gave higher mean panel scores for color, odor and taste (7.36-8.82) than untreated samples and the citric acid in the brine solution samples of all pasteurized sweet pepper puree. Also, it was the most preferred in all the studied characteristics. For example, sweet pasteurized red pepper puree samples received increasing scores with acetic acid-brine for color, odor and taste, the scores being 8.82, 7.72 and 7.54, respectively, these differences were significant ($p<0.05$) for both kind of pepper and acid-brine concentration.

On the contrary, the untreated pasteurized pepper puree samples and that pasteurized with citric acid had worst score for all sensory characteristics at kind of

Table 6: Effects of acid-brine pasteurization process on sensory evaluation in hot and sweet pepper puree

Pasteurized sweet pepper samples	Color (s)	Odor (s)	Taste (s)	Pungency (ns)	Appearance (s)
SGPP Control	6.63^{E}	6.81^{ABC}	6.09^{B}	2.62^{A}	6.91^{CD}
SGPP-0.25%AA	7.36^{BCDE}	6.81^{ABC}	6.18^{B}	3.62^{A}	7.36^{BCD}
SGPP-0.1%CA	7.00^{DE}	6.36^{C}	6.18^{B}	2.50^{A}	6.81^{CD}
SGPP-0.01%SO_2	7.09^{CDE}	6.45^{BC}	6.18^{B}	2.87^{A}	6.54^{D}
SRPP Control	8.27^{ABC}	7.45^{AB}	7.09^{AB}	3.87^{A}	7.36^{BCD}
SRPP - 0.25%AA	8.82^{A}	7.72^{A}	7.54^{A}	4.25^{A}	8.09^{AB}
SRPP-0.1%CA	8.54^{AB}	7.45^{AB}	7.00^{AB}	4.00^{A}	8.09^{AB}
SRPP-0.01%SO_2	8.82^{A}	7.54^{A}	7.36^{A}	2.87^{A}	8.54^{A}
SYPP Control	8.54^{AB}	6.91^{ABC}	7.09^{AB}	4.00^{A}	7.45^{ABCD}
SYPP- 0.25%AA	8.45^{AB}	7.72^{A}	7.54^{A}	4.00^{A}	7.91^{ABC}
SYPP- 0.1%CA	8.18^{ABCD}	7.45^{AB}	7.09^{AB}	2.75^{A}	7.54^{ABCD}
SYPP-0.01%SO_2	8.36^{AB}	7.36^{ABC}	7.81^{A}	3.62^{A}	7.63^{ABCD}
LSD*	1.198	1.026	1.159	3.318	1.168
Pasteurized hot pepper samples	**Color (s)**	**Odor (s)**	**Taste (s)**	**Pungency (s)**	**Appearance(ns)**
HGPP Control	7.8^{AB}	8.0^{AB}	7.7^{ABC}	8.4^{AB}	8.2^{A}
HGPP - 0.25%AA	8.8^{A}	8.3^{A}	8.4^{A}	8.5^{A}	8.4^{A}
HGPP-0.1%CA	8.6^{AB}	8.6^{A}	8.3^{AB}	8.4^{AB}	8.3^{A}
HGPP-0.01%SO_2	8.0^{AB}	8.0^{AB}	7.9^{AB}	8.2^{AB}	7.7^{A}
HRPP Control	7.6^{B}	7.8^{ABC}	7.9^{AB}	8.00^{ABC}	7.9^{A}
HRPP-0.25%AA	5.7^{C}	6.8^{BC}	6.7^{CD}	7.3^{BC}	6.2^{B}
HRPP-0.1%CA	6.0^{C}	7.9^{ABC}	6.4^{D}	7.0^{C}	6.5^{B}
HRPP-0.01%SO_2	8.0^{AB}	6.7^{C}	7.2^{BCD}	7.4^{ABC}	8.1^{A}
LSD*	1.180	1.228	1.144	1.138	0.975

* LSD = Least Significant Difference at 0.05 level; (s) = Significant; (ns) = Non-significant

pepper and all acid-brine pasteurization. This may be due to protein breakdown and as a result of pasteurized at the pepper surface. However, pasteurizing had a positive influence on acceptability of taste, color and odor of pepper puree. However, all sensory scores were in the acceptable range. These results closely or confirmed with the results of Lee *et al.* (2004) in red pepper powder and Sigge *et al.* (2001) who reported that the SO2 treatments showed only limited differences in their effect on visual color of dehydrated green bell peppers. In consequence, the acid-brine pasteurized pepper could be considered a strong product that includes a "pepper aroma or pungency" in accordance with consumer expectation for pepper.

Sensory evaluations for pungent taste and off-taste: The sensory scores of untreated and acid-brine pasteurized pepper puree for pungent taste is presented in Table 6. Sensory scores also showed that pungent taste of acid-brine pasteurized peppers was significantly ($p<0.05$) different from that of untreated pasteurized peppers puree. This result indicated that acid-brine pasteurization of pepper puree did not induce negative effects on the pungent taste characteristics of green and red pepper puree. However, the best score of pungency was 8.5 in hot green pasteurized pepper puree sample in the presence of acetic acid. On the contrary, sensory scores showed that pungent taste of acid-brine pasteurized sweet of green, yellow and red peppers puree was not significantly ($p<0.05$) different from that of untreated puree and different acid-brine pasteurization (Table 5). But it was significantly ($p< 0.05$) in different hot pasteurized green and red pepper puree from that of untreated and different acid-brine pasteurized puree samples, as seen in Table 6. Also, the sensory evaluation showed no significant difference in appearance between untreated (control) and acid-brine pasteurized hot of green and red pasteurized pepper puree. Further, the sensory evaluation showed high significant difference in pungent odor between untreated (control) and acid-brine pasteurized hot of green and red pasteurized pepper puree samples, as seen in Table 6. These results were not confirmed with the results of Lee *et al.* (2004) who found that the sensory evaluation differences were not significant ($p<0.05$) for pungent odor between untreated (control) and treated red pepper powder.

CONCLUSION

It is concluded that quality factors including total soluble solids contents, capsaicin content, ASTA, Tint and Hunter values could serve as good indices of general quality in green, yellow and red of sweet and hot pepper puree. However, the relationship between color (ASTA and tint units) and capsaicin and quality was high (0.94). It is concluded that capsaicin had a positive effect on deposition of ASTA values (total carotenoids) in pasteurized hot pepper puree and on content of tint units. From the above results it could be concluded that the Sulphites (SO_2) and citric acid -brine pasteurization process improved the color of pepper puree. In consequence, the acid-brine pasteurized pepper could be considered a strong product that includes a "pepper aroma or pungency" in accordance with consumer expectation for pepper products. These findings may lead to the development of a control strategy involving acid-brine pasteurization and the appropriate peppers (green, yellow and red), selected accordingly to the purpose.

REFERENCES

A.O.A.C., 2000. Official Methods of Analysis of the Association of Official Analytical Chemists, (17th Edn.), Association of Official Analytical Chemists, Arlington, Virginia, USA.

Anan T., H. Ito, H. Matsunga and S. Monma, 1996. A simple method for determining the degree of pungency of peppers. Capsicum and Eggplant Newslet., 15: 51-54.

ASTA, 1985. Official Analytical Method of the American Spice Trade Association. Englewood Clifs, New Jersey, pp: 41-42.

Bernal, M., A. Calderon, M. Pedreno, R. Munoz, A. Ros and F. Merino, 1993. Capsaicin oxidation by peroxidase from Capsicum annuum (var. annuum) fruits. J. Agric. Food Chem., 41: 1041-1045.

Buescher, R.W. and J.M. Hudson, 1986. Bound cations in cucumber mesocarp tissue as affected by brining and $CaCl_2$. J. Food Sci., 51: 135-137.

Cavella, S., G.G. Buonocore, M. Massera and P. Masi, 2000. Sensory evaluation of fresh pasta. Tecnica-Molitoria. 51: 1079-1084, 1091.

Gonzalez, M., E. Castano, E. Avila and E Gonzalez-de-Mejia, 1999. Effect of capsaicin from red pepper (*Capsicum* sp.) on the deposition of carotenoids in egg yolk. J. Sci. Food Agric., 79: 1904-1908.

Harrison, M.K. and N.D. Harris, 1985. Effect of processing treatments on recovery of capsaicin in jalapeno peppers. J. Food Sci., 50: 1764-1765.

Howard, L.R. and R.W. Buescher, 1990. Cell wall characteristics and firmness of fresh pack cucumber pickles affected by pasteurization and calcium chloride. J. Food Biochem., 14: 31-43.

Howard, L.R., P. Burma and A.B. Wagner, 1994b. Firmness and cell wall characteristics of pasteurized jalapeno pepper rings affected by calcium chloride and acetic acid. J. Food Sci., 59: 1184-1186.

Howard, L.R., R.T. Smith, A.B. Wagner, B. Villalon and E.E. Burns, 1994a. Provitamin A and ascorbic acid content of fresh pepper cultivars (*Capcicum annuum*) and processed jalapenos. J. Food Sci., 59: 362-365.

Hyung-Kweon-Yun, Kwang-Yong-Kim, Young-Cheol-Kim, Ji-Weon-Lee, Il-Seop-Kim, Keun-Chang-Yoo and H. Higashio, 2002. Change of some constituents along with the fruit maturity in *Capsicum* sp. J. Korean Soc. Horticul. Sci., 43: 39-42.

Jiang, Y. and J. Fu, 1998. Inhibition of polyphenoloxidase and the browning control of Litchi fruit by glutathione and citric acid. Food Chem., 62: 49-52.

Kim, S., J. Park and K. Hwang, 2002. Quality attributes of various varieties of Korean red pepper powders (Capsicum Annuum L.) and color stability during sunlight exposure. J. Food Sci., 67: 2957-2961.

Lee, J., T. Sung, K. Lee and M. Kim, 2004. Effect of gamma-irradiation on color, pungency and volatiles of korean red pepper powder. J. Food Sci., 69: C585-C592.

Lee, Y. and L. Howard, 1999. Firmness and Phytochemical Losses in Pasteurized Yellow Banana Peppers (*Capsicum annuum*) As Affected by Calcium Chloride and Storage. J. Agric. Food Chem., 47: 700-703.

Minguez, M. and D. Hornero, 1993. Separation and quantification of the carotenoid pigment in red peppers (*Capsicum annuum* L.), paprika and oleoresin by reversed-phase HPLC. J. Agric. Food Chem., 41: 1616-1620.

Minguez-Mosquera and Hornero-Mendez, 1994. Formation and transformation of pigments during the fruit ripening of Capsicum annuum cv. bola and agridule. J. Agric. Food Chem., 42: 38-44.

Olmos, E., A. Piqueras, J.R. Martinez-Solano and E. Hellin, (1997). The subcellular localization of peroxidase and the implication of oxidative stress in hyperhydrated leaves of regenerated carnation plants. Plant Sci., 130: 97-105.

Palou, E., A. Lopez-Malo, G. Barbosa-Canovas, J. Chanes-Welti and W. Swanson, 1999. Polyphenoloxidase and color of blanched and high hydrostatic pressure treated banana puree J. Food Sci., 64: 42-45.

Pizzocaro, F., D. Torreggiani and G. Gilardi 1993. Inhibition of apple Polyphenoloxidase (PPO) by ascorbic acid, citric acid and sodium chloride. J.Food Process. Preservation, 17: 21-30.

Price, K.R., J.R. Bacon and J.C. Rhodes, 1997. Effect of storage and domestic processing on the content and composition of flavonol glucosides in onion (*Allium cepa*). J. Agric. Food Chem., 45: 938-942.

Rajput, J. and Y. Parulekar, 1998. Capsicum. Handbook of vegetable science and technology, edited by Salunkhe K. and Kadam S. Ch., Marcel Dekker Inc. New York, 8: 203-224.

Reineccius, G., 1994. Source Book of Flavors. Second Ed. Chapman and Hall, New York, pp: 928.

Ricardo, G. and P. Jose, 1996. Evolution of color during the ripening of selected varieties of paprika pepper (*Capsicum annum* L.). J. Agric. Food Chem. 44: 2049-2052.

Richard, J., B. Gouri, 1987. Statistics Principles and Methods. John Wiles and Sons, New York, pp: 403-427.

Russo, V. and L. Howard, 2002. Carotenoids in pungent and non-pungent peppers at various developmental stages grown in the field and glasshouse. J. Sci. Food and Agric., 82: 615-624.

Saldana, G. and R. Meyer, 1981. Effects of added calcium on texture and quality of canned jalapeno peppers. J. Food Sci., 46: 1518-1520.

Sapers, G. and F. Douglas, 1987. Measurement of enzymatic browning at cut surfaces and in juice of raw apple and pear fruits. J. Food Sci., 52: 1258-1262, 1285.

Se-Won-Park, Hyun-Ok-Kim, Tae-Hoon-Kim, In-Kwon-Lee and Se-Jin-Hong, 2003. Relationship between physicochemical quality attributes and sensory evaluation during ripening of green pepper fruits. J. Korean Soc. Horticul. Sci., 44 : 325-329.

Sigge, G., C. Hansmann and E. Joubert, 2001. Effect of storage conditions, packaging material and metabisulphite treatment on the color of dehydrated green bell peppers (*Capsicum annuum* L.). J. Food Quality, 24: 205-218.

Sun, N. and K. Song, 2003. Effect of nonthermal treatment on the molecular properties of mushroom polyphenoloxidase. Food Chem. Toxicol., 68: 1639-1643.

Suzuki, T. and K. Iwai, 1984. Constituents of red pepper spices. In Alkaloids, Academic Press: New York, pp: 227-299.

Tung-Sung C., M. Siddiq, Nirmal K. Sinha and Jerry N. Cash, 1995. Commercial pectinase and the yield and quality of Stanley Plum juice. J. Food Process. Preser., 19: 89-101.