Optimizing Browning Capacity of Eggplant Rings during Storage before Frying

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Abstract: Deterioration of fresh eggplant rings was demonstrated as a rapid increase of enzymatic browning and with an obvious browning. The effect of thermal and chemical pretreatments on enzymatic browning and frying quality of eggplant rings were investigated. Thermal pretreatment using water or steam blanching; and chemical pretreatment by dipping in different concentrations of SO_2, chitosan, carboxy methylcellulose (CMC) or sodium chloride. Changes in enzymatic browning in fresh eggplant rings during storage at 25°C for 24 hrs were investigated by determining rings colour as a capacity of browning and colour parameters. Best colour values of eggplant rings were found in SO_2 and steam blanching pretreatments; hence the quality of fresh eggplant rings was able to maintain for up to 24 hours at 25°C. The inhibitory effect of various thermal and chemical pretreatments on eggplant rings was found to decrease in the following order SO_2 > steam blanching > water blanching > coated chitosan > coated CMC > sodium chloride. Frying eggplant rings at 180°C/4 min for SO_2, chitosan or steam blanching was able to optimize the quality of eggplant rings regarding to L*, a*, C*, BI, ΔE-values and non-enzymatic browning ($A_{420\ nm}$). The fried pre-treated eggplant rings with SO_2 or water blanching gave higher mean panel scores (7.8–8.6) in all sensory characteristics compared to other pre-treated samples.

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1. Introduction:

Eggplant (*Solunum melongena* L.) is a plant of the family Solanaceae (also known as the nightshades) and genus Solanum. It bears a fruit of the same name, commonly used in cooking and frying. The fruit is capable of absorbing large amounts of frying oils. Production of eggplant is highly concentrated, with 85% of output coming from five countries. China is the top producer (56% of world output) and India is second (26%); Egypt, Turkey and Indonesia produce the remains amount. Its world production is around 32 million tons (FAOSTAT, 2009).

The quality of Eggplant attributes to violet surface without defects, and absence of seed (Cantwell and Suslow, 2009). Fruit deterioration during long term storage is associated with pulp browning caused by the oxidation of phenolic compounds. The level of phenolics has been shown to correlate with browning in different eggplant varieties (Prohens *et al.*, 2007). In addition, loss of cellular compartmentalization has been shown to accelerate browning by increasing peroxide levels and oxygen partial pressure within the tissues, and by releasing phenolics stored in the vacuoles, which can then be readily available for oxidation by polyphenol oxidases and peroxidases (Beaulieu *et al.*, 1999; Concelln̈ *et al.*, 2004). Low temperature storage is effective for reducing browning reactions and for delaying eggplant fruit deterioration. However, refrigeration cannot be fully exploited because eggplants are chilling sensitive and should not be stored for long periods below 7–10°C (Concelln̈ *et al.*, 2007). Most fruits and plants originating in tropical and subtropical regions are prone to physiological injury when exposed to temperatures below 12.5°C and above their freezing point. Eggplant, as a tropical fruit has sensitivity to chilling injury (CI), is generally associated with problems in storage and processing. One of these symptoms is the darkening of seeds and pulp tissue. More severe symptoms include pitting and browning of skin or surface scald (Cantwell & Suslow, 1999). Biochemical and nutritional characteristics of fruits are changed due to the presence of brown pigments. Moreover, browning, after mechanical or physiological injury during harvest, processing or cold storage affects consumer acceptability and palatability because of unpleasant appearance and concomitant off-flavour development (Das *et* al., 1997; Garcĭa-Carmona *et al*, 1988). In general, browning is caused by enzymatic oxidation of natural phenolic compounds, and polyphenol oxidase (PPO; EC 1.14.18.1) is a key enzyme in this degradation.

The main problem facing eggplant rings production is the quality assurance of colour, enzymatic browning and maintains palatability.

Therefore, the present study aimed to investigate the effectiveness of thermal and chemical pretreatments in maintaining the quality of fresh eggplant rings in terms of colour as a brown capacity and % inhibition during storage at room temperature (25ºC) for 24 hours. The effect of frying at 180°C for 4 min on colour characteristics and sensory evaluation of pretreated eggplant rings was also studied.

2. Materials and methods

Preparation of eggplant rings:

Eggplant *(Solunum melongena L. family Solanaceae)* samples were obtained from local market during the fall and winter of 2011 and stored for using at 4ºC. One hr prior to use, fruits were removed from the refrigerator and equilibrated to room temperature. Each eggplant was rinsed with water, peeled, sectioned to rings at least 1cm from the skin end (to exclude the effects of bruising) and exposing fresh surface.; then treated separately with chemical solutions (chitosan, CMC, SO_2 or sodium chloride) or with water or steam blanching.

Evaluation of browning capacity or brown inhibitors:

Colorimetry was performed with spectro-colorimeter (Tristimulus Colour Machine) using the CIE lab colour scale. This colour assessment system is based on the Hunter L^*, a^{*-} and b^* coordinates. To determine the suitability of the tristimulus reflectance procedure for evaluating browning inhibitors applied to cut surface of eggplant rings. Treatments were applied to 3 rings and 3 rings as a control, using only one eggplant fruit. Samples were dipped for 20 min in freshly prepared carboxy methylcellulose (CMC) and chitosan (0.5, 1 and 2%), NaCl (0.5, 1 and 2%), and sodium meta bisulfate (0.01, 0.05 and 0.1%). Peeled eggplant rings were thermal treated (water blanching and steam blanching for 1, 3 and 5 minutes), then the rings were drained, blotted dry with absorbent tissue and held in covered glass dishes to minimize dehydration at the cut surface for 24 hours at room temperature (25ºC) during which time tristimulus reflectance measurements were carried out at intervals. Values of the tristimulus coordinates in the L*, a* and b* values were recorded at 1, 5, 10, 15, 30, 45, 60, 90, 120 and 240 min; and after 24 hours. The tristimulus coordinates were plotted against time, and the slopes of linear portions of these curves were obtained by linear regression as described by the method of Sapers and Douglas (1987).

Frying experiment process:

Fresh eggplant rings samples were dipped separately in fresh prepared CMC (2%), chitosan (2%), NaCl (4%), or sodium meta bisulfate (0.1%) for 20 min; or blanched separately in water or steam for 3 minutes), then the rings were drained. Untreated or pretreated eggplant rings were fried at 180°C for 4 min in a controlled temperature deep-fat fryer (Philips comfort, Germany) filled with 1.5 L of purified sunflower oil (Arma Crystal Company, Egypt) enriched with vitamins A and D, and contained 1.8g saturated fat, 3.8g mono-unsaturated fat and 8.4g poly-unsaturated fatty. Oil was replaced by fresh oil after four frying batches; three eggplant rings were fried in each batch. Colour characteristics and sensory evaluation (Garcĭa *et al*., 2002 and Bertolini *et al*., 2008) were determined in fried eggplant rings samples.

Non-enzymatic browning determination:

Non-enzymatic browning was measured spectrophotometrically by 4054 - UV/Visible spectrophotometer, (LKB-Biochrom Comp., London, England), as absorbance at 420nm using ethanol as blank according to the method of Stamp & Labuza (1983) and Birk *et al*, (1998).

Colour determination of eggplant rings:

Fresh and fried eggplant rings colour was determined according to Hunter (1975). Colour of Egyptian fresh and fried eggplant rings was measured using spectro-colorimeter (Tristimulus Colour Machine) with the CIE lab colour scale (International Commission on Illumination) as mentioned by Hunter (1975) and Sapers & Douglas (1987).

Sensory evaluation:

Twelve trained panelists were selected for sensory evaluation of the studied pretreated and fried eggplant ring samples. Colour, flavour, taste, texture, and appearance of the fried eggplant ring samples were determined using a ten point scale (10 = excellent and 1 = bad) as described by Bertolini *et al*., (2008). The limit of the acceptability was 5.

Statistical analysis:

The obtained results were analyzed statistically using the analysis of variance (ANOVA with two ways) and the Least Significant Difference (LSD) as described by Richard and Gouri, (1987).

3. Results and discussion

Effect of chemical and thermal pretreatments on browning of fresh eggplant rings stored at room temperature:

Browning of eggplant rings was measured by a* (green-red) and L* (lightness-darkness). A decrease in L*-value and an increase in a*-value are indicative of browning (Monsalve, *et al*, 1993). The effect of using anti-browning agents (chemical and thermal pretreatments) on inhibiting the browning reactions during storage of eggplant rings for 24 hours at room temperature (25ºC) was measured and graphically represented in Figs (1a, b). These figures illustrates the changes in the colour of eggplant rings in terms of a*-values over 24 hours as affected by the following treatments: thermal (steam and water), SO_2 at 0.01, 0.05 and 0.1%, chitosan and CMC at 0.5, 1 and 2% and sodium hydroxide (NaCl) at 1, 2 and 4%. Figures (1a, b) showed that, chemical treatment (SO_2 and chitosan) and thermal treatment (steam and water) were able to prevent eggplant rings from browning, where lowest a*-value (< -0.55) was obtained after storage for 24 hrs at room temperature (25ºC). At the same time, browning of untreated eggplant rings (a*-value) increased sharply to >12.38. On the other hand, Figures (1a, b) showed that, the most effective anti-browning was found in case of using SO_2 as a chemical pretreatment, and also by using steam as a thermal pretreatments. These results explained the higher anti-browning agent of chemical and thermal pretreatments than untreated eggplant rings during storage at room temperature for 24 hrs.

From the obtained results, it could be concluded that, SO_2 (0.1%) and chitosan (2%) were the most effective chemical treatments for inhibiting enzymes, obtaining good colour and lowering non-enzymatic browning in eggplant rings during storage at room temperature.

Effect of thermal and chemical pretreatments on changes of colour characteristics of fresh eggplant rings:

Hunter colour parameters showed that, fresh eggplant rings appeared at the light green region, while pretreated samples showed clear signs of degreening during storage at room temperature (25ºC). Visually, fresh eggplant rings showed a darker colour than treated rings. Degreening appeared with a rapid increase of a*-value in eggplant rings (Figures. 1a, b). However, thermal treatment of eggplant rings inhibited the occurrence of degreening in eggplant rings during storage. Thermal, coated chitosan and SO_2 addition have a preventive effect against any changes that might occur in colour indicating a lowest - a* value especially during the late period of storage at room temperature 25ºC. Browning was observed in the control sample representing a rapid increment in a* value within the first 4 hrs. Afterward, the colour of eggplant rings became lighter with decrement in - a* values during storage at room temperature (Figures 1a, b). This result indicated that thermal and chemical pretreatments inhibited browning. The decrease of - a* values during the late period of storage could be related with sedimentation or breakdown of brown compounds.

Effect of various thermal and chemical treatments on colour characteristics of Fresh eggplant rings:

The surface colour of eggplant rings was measured with a colour difference meter (Hunter Lab colour scale). Under all tested conditions, SO_2 treatment had higher efficient values based on a*-values than A420 measurements, where the other anti-browning behaved an opposite trend. For all tested samples the increase in the concentration of the anti-browning agents revealed increase in the inhibition efficient. Such trend is in agreement with previous studies of Janovitz-Klapp (1990), and Ozoglu and Bayindirh, (2002). The inhibitory effect of the studied anti-browning agents on eggplant rings was based on measurements at their maximum concentrations as shown in tables 1 and 2. Bothe tables showed a decrease at the following order SO_2 > steam blanching > water blanching > coated chitosan > coated CMC > sodium hydroxide. It is obvious that thermal pre-treatments of eggplant rings increased the development of red colour a* value as non-enzymatic browning. The Hunter colour values of steam blanching samples in eggplant rings were lower than those of water blanching samples. Also, the Hunter colour value of SO_2 pre-treatment in eggplant rings was lower than that of coated chitosan, coated CMC and sodium hydroxide pre-treatments. These results indicated that the browning (redness) increased in water blanched samples than in steam blanched samples for eggplant rings. According to our results, the main colour change in untreated and pre-treated eggplant rings of thermal and chemical treatments was due to increase in browning index (BI) and a*-value, which were in high correlation to browning measurement. Also, other colour parameters such as Hue angle and chroma indicated that heat pre-treatment caused a slight colour change. Heat treatment (blanching) showed that, water blanching had a BI lower than that of steam blanching on eggplant rings. But, BI values in SO_2 samples were lower than those of coated chitosan and coated CMC samples as shown in Figure (7b). These results are in good agreement with those of Janovitz-Klapp *et al* 1990; and Ozoglu and Bayindirh (2002). Generally, pre-treatments of coated chitosan, coated CMC and sulfitting improved the colour of eggplant rings (Figures 2b-7b). Sulfur dioxide has been shown to be effective for preventing browning by combining with carbonyl groups. From the above mentioned results, it could be concluded that, the pretreated eggplant rings with sulfites (SO_2) had the best colour values (a* and BI) and lower enzymatic browning compared to the other pre-treatments, as shown in Tables (1 and 2). The optimum conditions of thermal and chemical pre-treatment for improving the quality of eggplant rings (inhibition enzymatic browning - good colour) were found in case of using steam and water blanching for 5 min, SO_2 (0.1 ppm), chitosan (2%), CMC (2%) and sodium hydroxide (4%), as seen in Figures (1a, b - 7a, b).

Effect of thermal and chemical pretreatments on % Inhibition of browning in fresh eggplant rings

As shown in Table (1 and 2), thermal (steam and water), SO_2 addition and coating with chitosan reduced enzymatic browning of fresh eggplant rings, and chemical pretreatments at high concentration were more effective than thermal pre-treatment. Enzymatic browning of untreated fresh eggplant rings was about hundred fold higher than that of chemical and thermal treated rings. On the other hand, addition of 0.1% SO_2 and 2% coated chitosan increased inhibition percentage to 100 and 78%, respectively.

Table (1): Effect of thermal pretreatments on the percentage inhibition of enzymatic browning in eggplant rings

Samples	% Inhibition	Standard Deviation (n=3)
Untreated sample	0.00	1.05
Water 1min.	90.77	15.87
Water 3 min.	90.77	23.05
Water 5 min.	97.09	8.87
Steam 1 min.	77.79	7.75
Steam 3 min.	95.67	11.46
Steam 5 min.	100	15.09

Table (2): Effect of Chemical pretreatments on the percentage inhibition of enzymatic browning in eggplant rings

Samples	% Inhibition	Standard Deviation (n=3)
Untreated sample	0.000	1.18
0.5% chitosan	50.00	6.52
1% chitosan	62.50	8.12
2% chitosan	78.03	9.44
0.5% CMC	53.03	8.17
1% CMC	66.67	7.28
2% CMC	68.56	9.57
0.01% SO_2	48.48	6.78
0.05% SO_2	98.48	3.68
0.1% SO_2	100.0	4.97
1% NaCl	9.47	10.19
2% NaCl	32.95	9.35
4% NaCl	49.62	13.46

High temperature of thermal pretreatments inactivated enzymatic browning, which confirmed the observation of Va´mos-Vigya´zo (1981), who reported that PPO enzymes are destroyed at 80ºC although they are relatively heat labile. These inhibitory effects of thermal (steam and water) and chemical (SO_2 and coated chitosan) pretreatments on enzymatic browning were related with the prevention of PPO enzyme activity. Browning is mostly the result of the activity of PPO enzyme acting on phenolic compounds to produce dark coloured polymers when sugarcane is crushed to release the juice (Vickers *et al*., 2005).

Effects of thermal and chemical pretreatments on colour characteristics and non-enzymatic browning (A_{420nm}) of fried eggplant rings.

The surface colour of fried eggplant rings was measured with a colour difference meter, using the Hunter Lab colour scale. The Hunter colour values of fried eggplant rings were determined immediately after frying. Changes in L* values were inversely proportional to the changes in a*values of the Hunter colours. Absorption at 420 nm, the CIE L*, a*, b* colour parameters, hue angle, chroma and BI were found to be suitable indicators for the brown pigment formation because of non-enzymatic browning after processing, as seen in Table (3). The a* values and BI for SO_2, NaCl and steam -treated fried eggplant rings were low in contrast to high values for untreated and other treated fried eggplant. The CIE a* and colour parameters like hue angle (H*), chroma (C*), browning index (BI) and non-enzymatic browning (A_{420nm}) of fried eggplant samples had the lowest values in SO_2 treated samples compared with the untreated and other treated samples in fried eggplant, as seen in Table (3). Also, it was generally found that steam blanching, NaCl and SO_2 treatments improved the colour of fried eggplant rings. However, SO_2, NaCl and steam blanching samples had the high increase in colour as optical density (A420nm) compared with the untreated and other treated samples in fried eggplant. The increase in colour (browning as A420nm) could be attributed to the reaction occurred between amino groups and active carbonyl groups (Maillard reaction) after thermal treatments (blanching). From the above mentioned results, it could be concluded that the pretreated eggplant rings with sulphites (SO_2), NaCl and steam blanching have the best colour values and higher nonenzymatic browning as compared with the other treatments of fried eggplant, as seen in Table 3. The results are in accordance with those of Janovitz-Klapp *et al*. (1990) and Ozoglu and Bayindirh (2002).

Table (3): Effect of chemical and thermal pretreatments on colour characteristics of fried eggplant rings.

Samples	L*	a*	b*	ΔE	C*	H*	BI	NEB (A_{420nm})
Untreated	45.70 ±3.0	9.0 ±0.8	19.69 ±1.0	54.23 ±2.4	21.66	65.36	127.06	5.64 ±1.1
SO_2 0.1%	46.48 ±2.6	8.49 ±0.7	18.19 ±1.3	50.90 ±2.0	20.07	64.98	113.34	7.05 ±1.0
Chitosan 2%	49.63 ±5.0	9.25 ±1.6	20.99 ±2.2	52.30 ±3.6	22.94	66.22	123.15	6.75 ±1.6
CMC 2%	49.50 ±1.1	9.10 ±0.6	21.14 ±1.1	52.42 ±1.7	23.02	66.71	124.05	6.51 ±0.8
NaCl 4%	56.04 ±6.3	7.21 ±1.6	22.88 ±2.5	48.64 ±3.4	23.99	72.51	110.89	9.21 ±2.1
Water 3min	46.44 ±5.2	8.61 ±1.0	19.45 ±3.2	53.21 ±1.6	21.27	66.12	121.78	5.99 ±0.8
Steam 3min	43.95 ±5.4	6.87 ±0.7	16.68 ±2.3	51.40 ±2.9	18.04	67.61	106.38	6.51 ±1.4

Effects of thermal and chemical pretreatments on sensory evaluation of fried eggplant rings:

Sensory attributes are of great importance to measure consumer attitudes and their influence on food choice and acceptability. The colour of fried food is the first quality attribute used to judge acceptability of fried products. A two-way ANOVA after frying process of the variables influenced by the pre-treatments, panelists and frying process is shown in Table (4). Flavour scores differ significantly after frying process, where a positive correlation was noticed between the flavour score of pretreated samples. The obtained result represents the statistical analysis of colour, odour, taste, texture and appearance of fried eggplant rings with thermal and chemical pre-treatments. Fried eggplant rings of different pre-treated samples were differed significantly ($P < 0.05$). The fried pre-treated eggplant rings with SO_2 and water blanching gave higher mean panel scores (7.8–8.6) in all the sensory characteristics than other pre-treated samples. Texture and appearance of Fried eggplant rings characterized with their higher scores in pretreated steam blanching for 3 min. On the contrary, the untreated fried eggplant sample and that pre- treated with CMC and NaCl had lower scores in all sensory characteristics. This may be due to protein breakdown and dehydration on eggplant surface. In generally, frying had a positive influence on acceptability of colour, flavour and texture acceptability of eggplant rings. Moreover, all sensory scores of samples were in acceptable range (greater than 5). These results agreed with those of Perez & Albisu (2002) and Gonulalan et al. (2003).

Table (4): Effect of chemical and thermal treatments on sensory evaluation of fried eggplant rings.

Fried eggplants rings	Colour	Taste	Flavour	Texture	Appearance
Fried eggplant (control)	8^{AB} ±1.2	7.1^{B}±1.05	7.8^{B}±0.97	8^{AB}±0.1	6.7^{C}±1.3
Treated with Chitosan 2%	6.3^{C}±2.1	7^{B}± 1.2	6.2^{C}±0.97	7^{B}±1.2	7.6^{B}±1.1
Treated with CMC 2%	5.6^{D}±3.2	5.7^{D}±3	5.7^{D}±3.1	5.8^{D}±2.7	5.6^{D}±2.8
Treated with SO_2 0.1%	8.1^{A}±1.1	8^{A}±1	8.6^{A}±0.5	8.4^{A}±0.7	8.2^{A}±1.1
Treated with NaCl 4%	5.4^{D}±2.3	5.9^{D}±2.8	7.1^{B}±1.7	6.8^{C}±2.2	6.1^{D}±3.2
Treated with Water 3min	7.8^{B}±1.4	7.8^{B}±1.4	7.8^{B}±1.4	7.6^{B}±1.7	7.8^{B}±1.4
Treated with Steam 3min	6.2^{C}±0.8	7^{B}±0.7	6.8^{C}±0.7	7^{B}±0.5	7^{B}±0.5

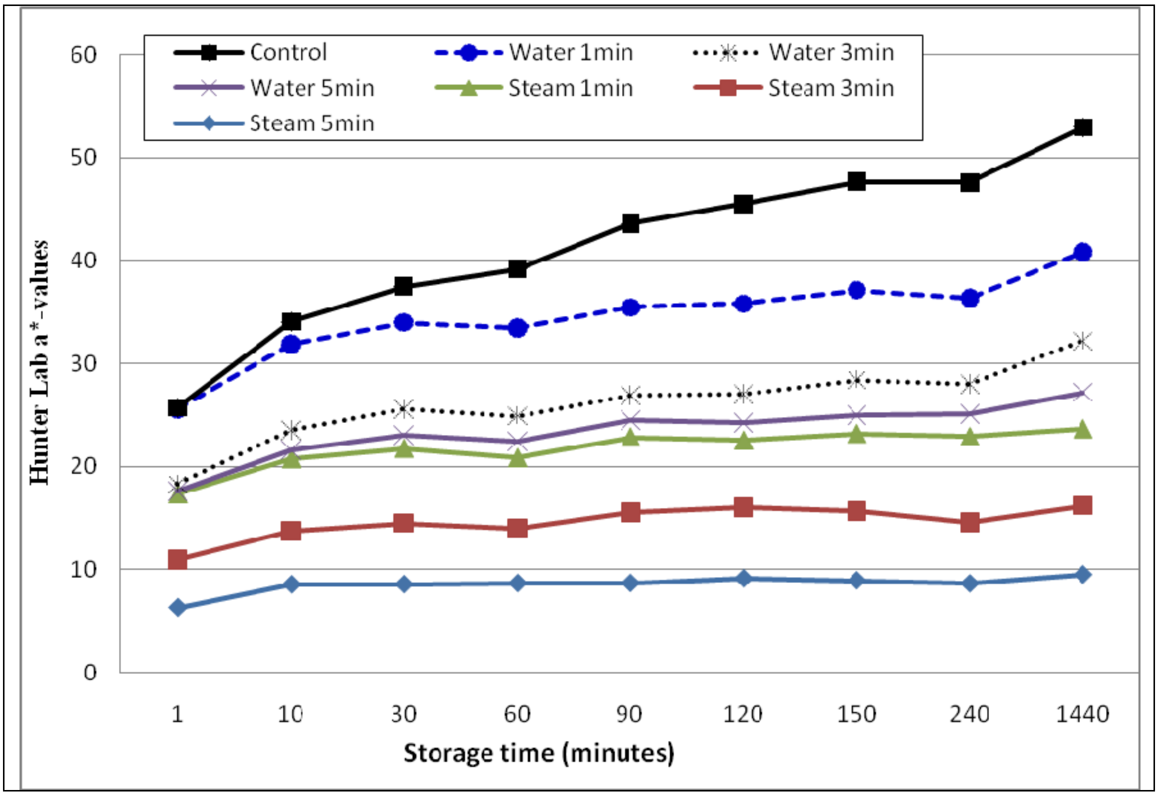

Figure (1a): Effect of thermal pretreatments on a*-values during storage at room temperature in fresh eggplant rings.

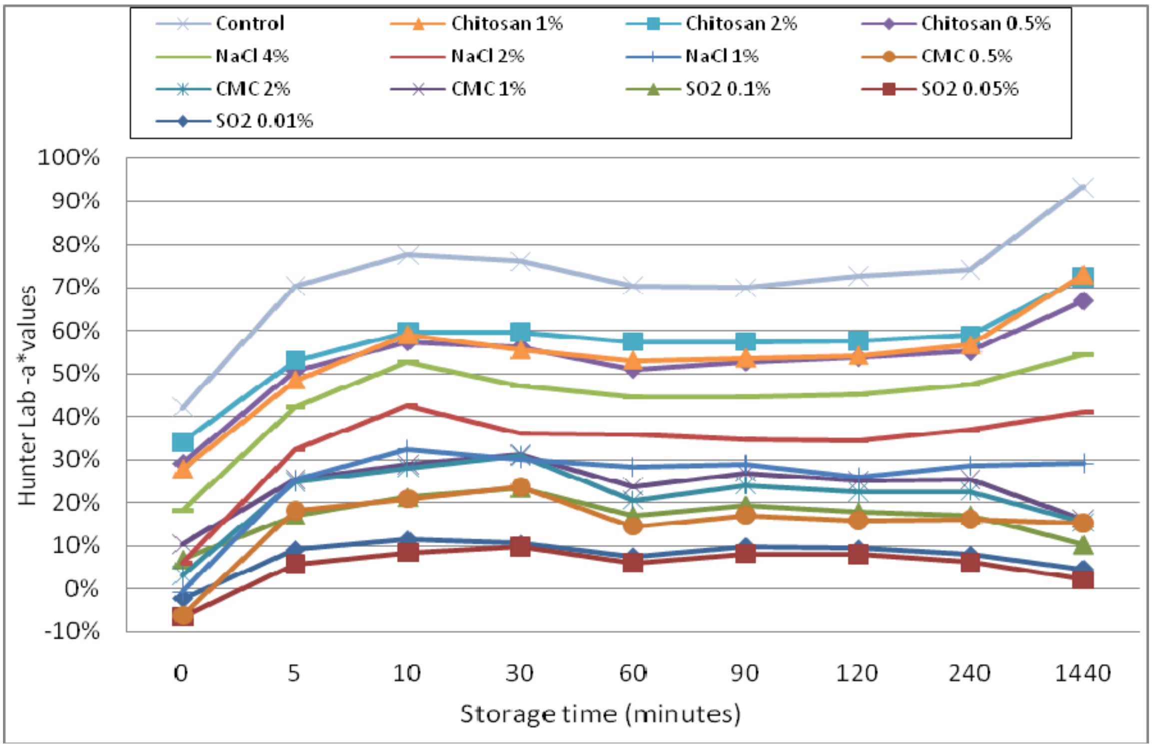

Figure (1 b): Effect of chemical treatments on a*-values during storage at room temperature.

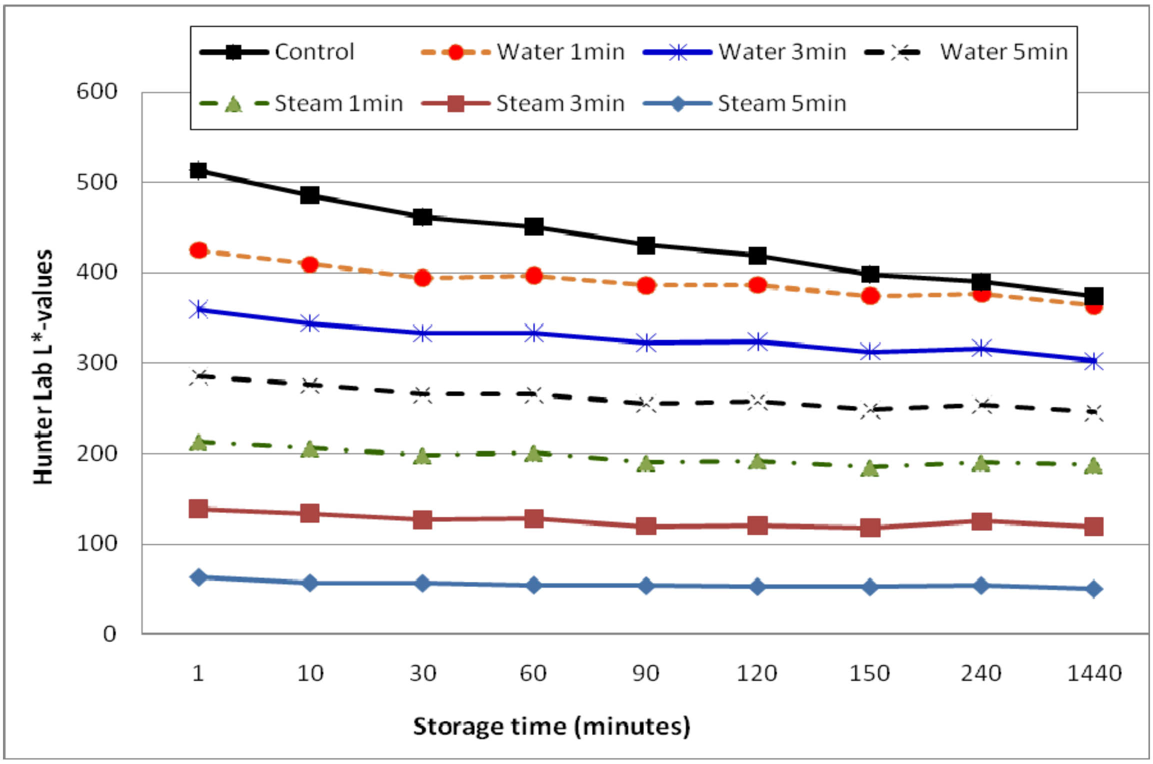

Figure (2 a): Effect of thermal pretreatments on L*-values during storage at room temperature in fresh eggplant rings.

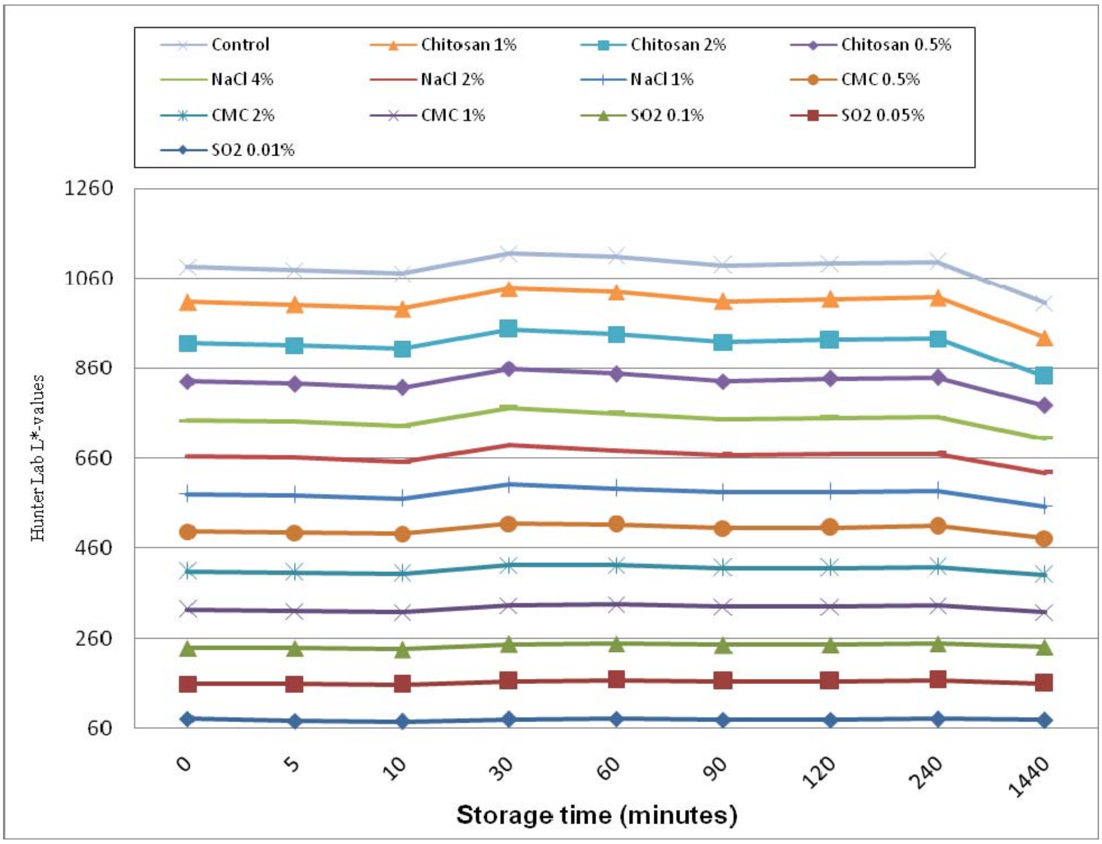

Figure (2b): Effect of chemical treatments on L*-values during storage at room temperature 2.

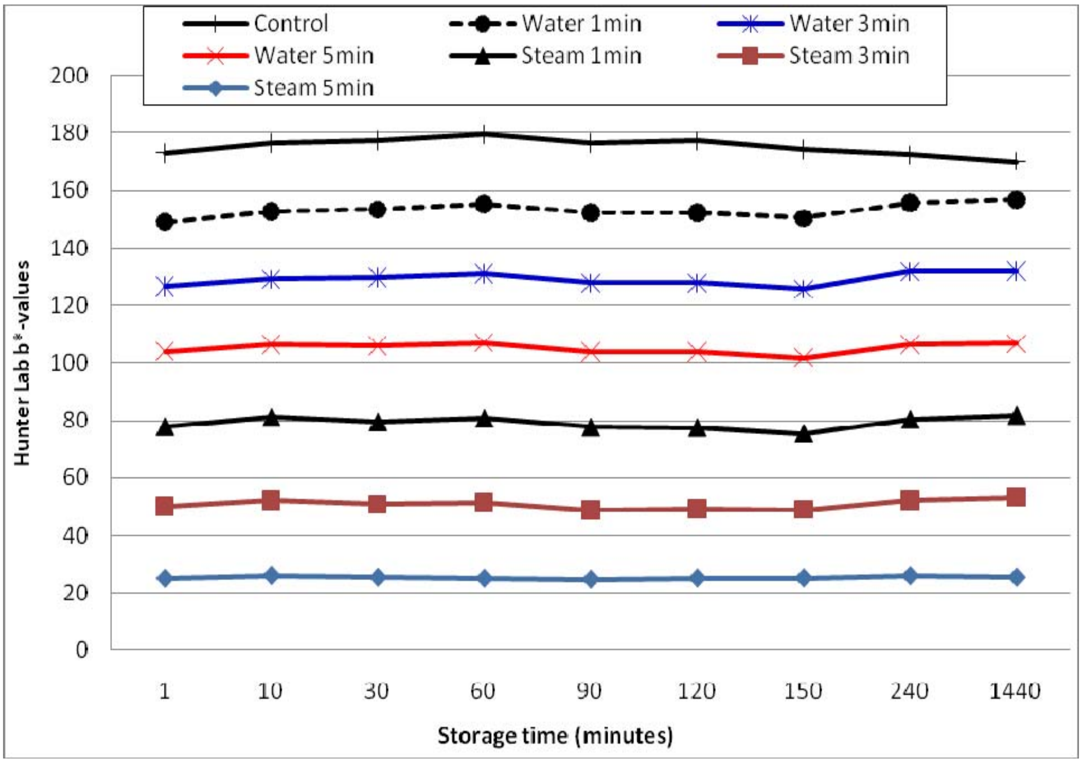

Figure (3 a): Effect of thermal pretreatments on b*-values during storage at room temperature in fresh eggplant rings.

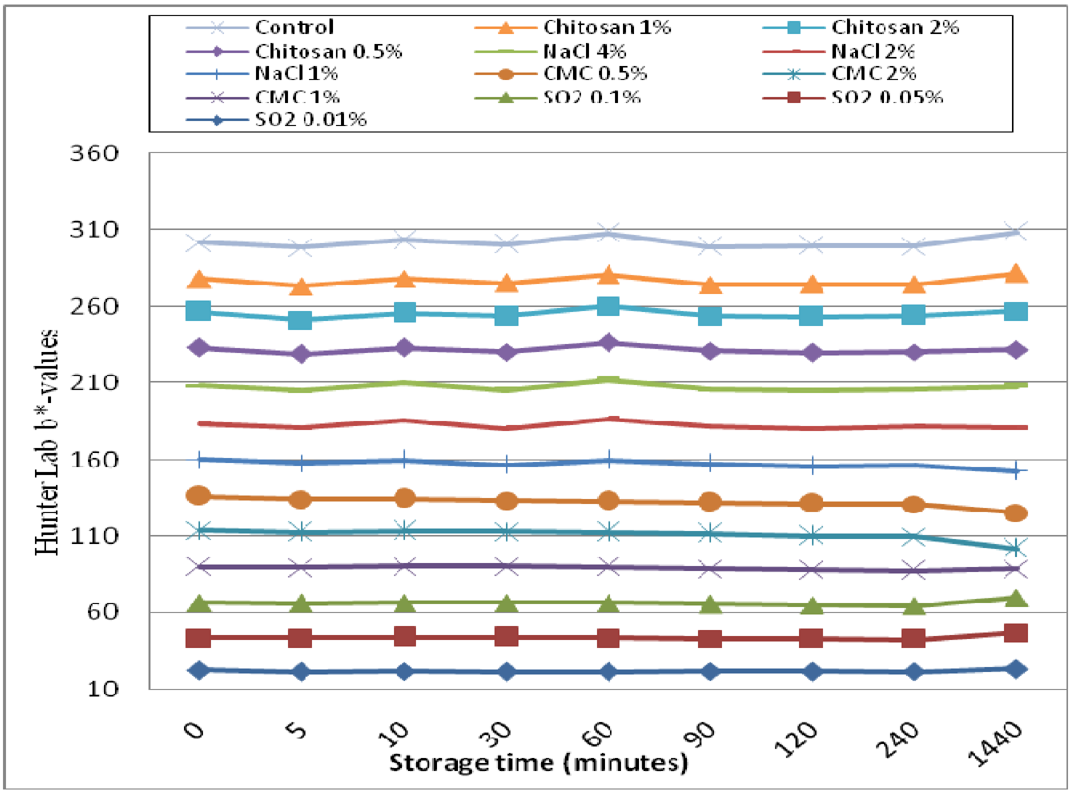

Figure (3b): Effect of chemical treatments on b*-values during storage at room temperature.

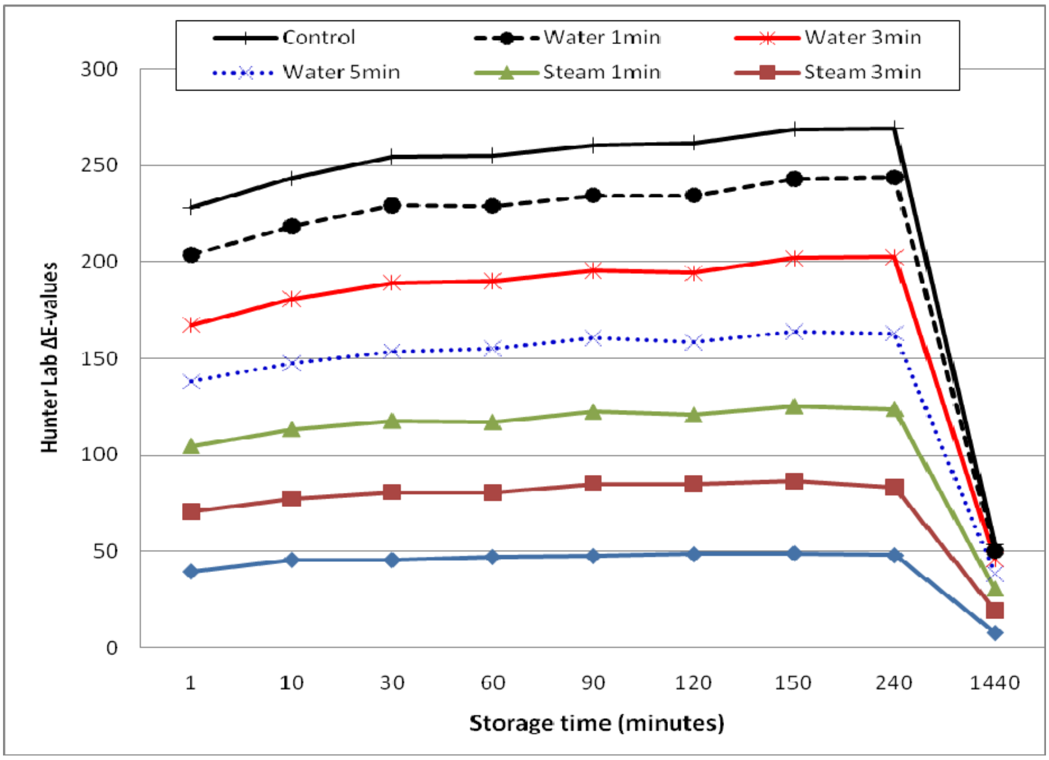

Figure (4 a): Effect of thermal pretreatments on ΔE *-values during storage at room temperature in fresh eggplant rings.

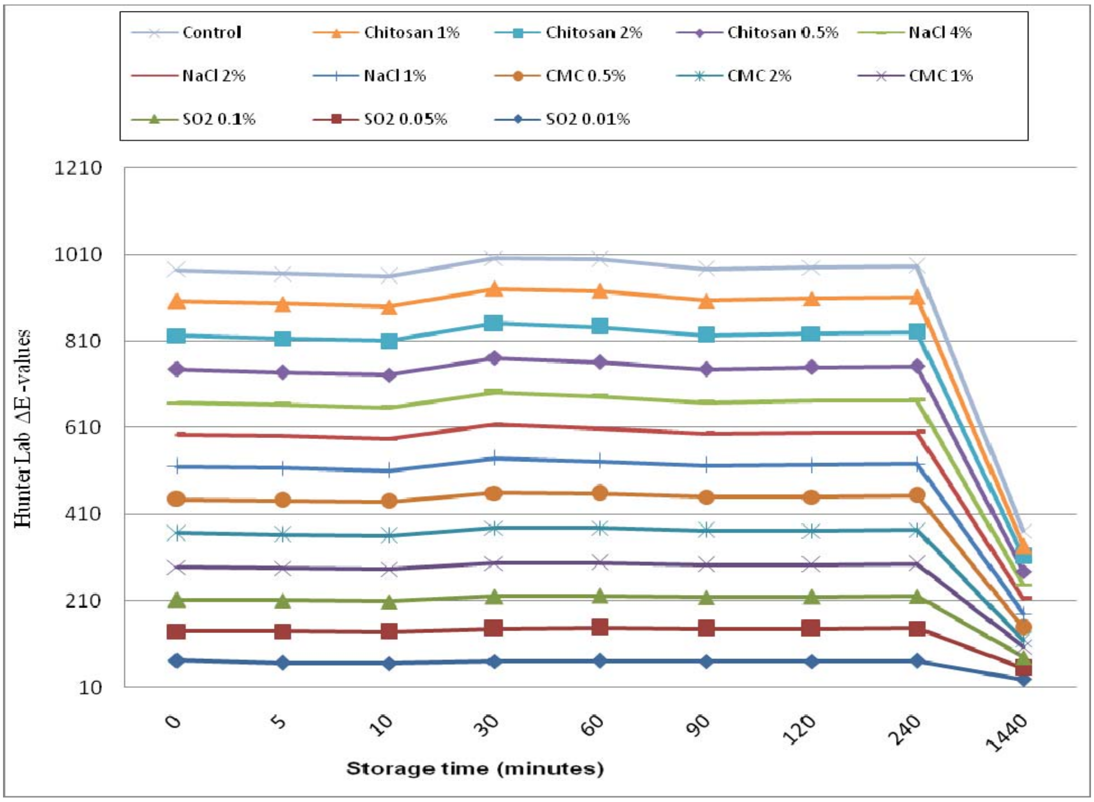

Figure (4b): Effect of chemical treatments on ΔE*-values during storage at room temperature.

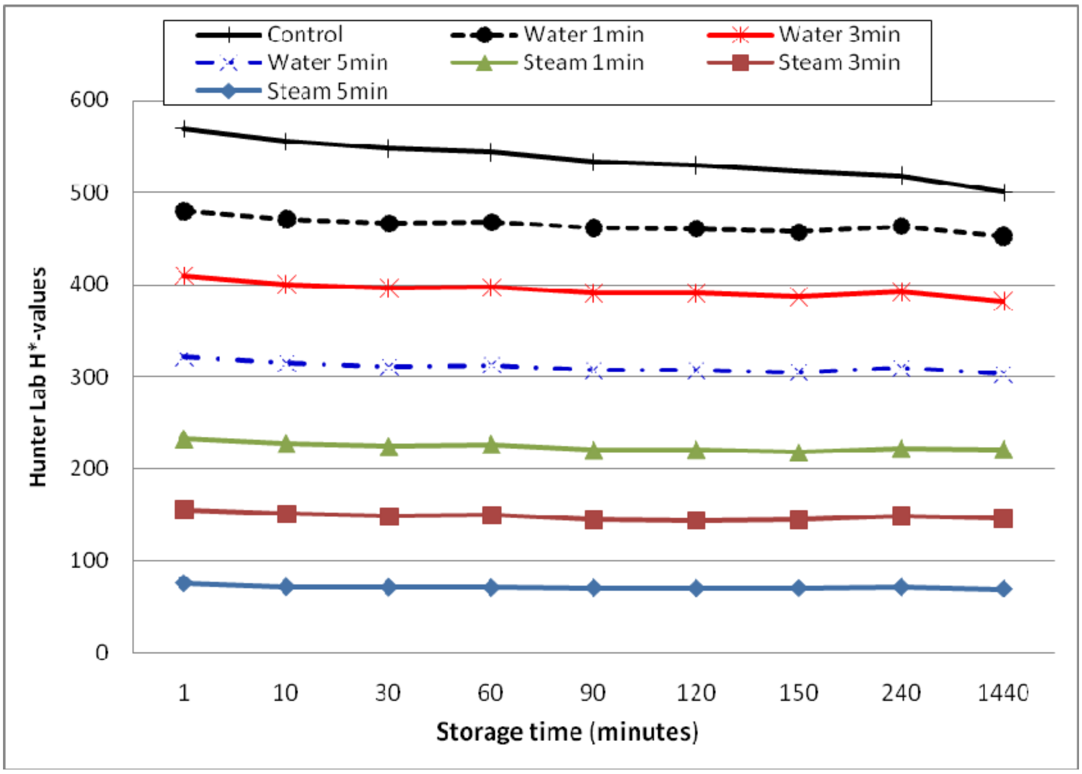

Figure (5 a): Effect of thermal pretreatments on H *-values during storage at room temperature in fresh eggplant rings.

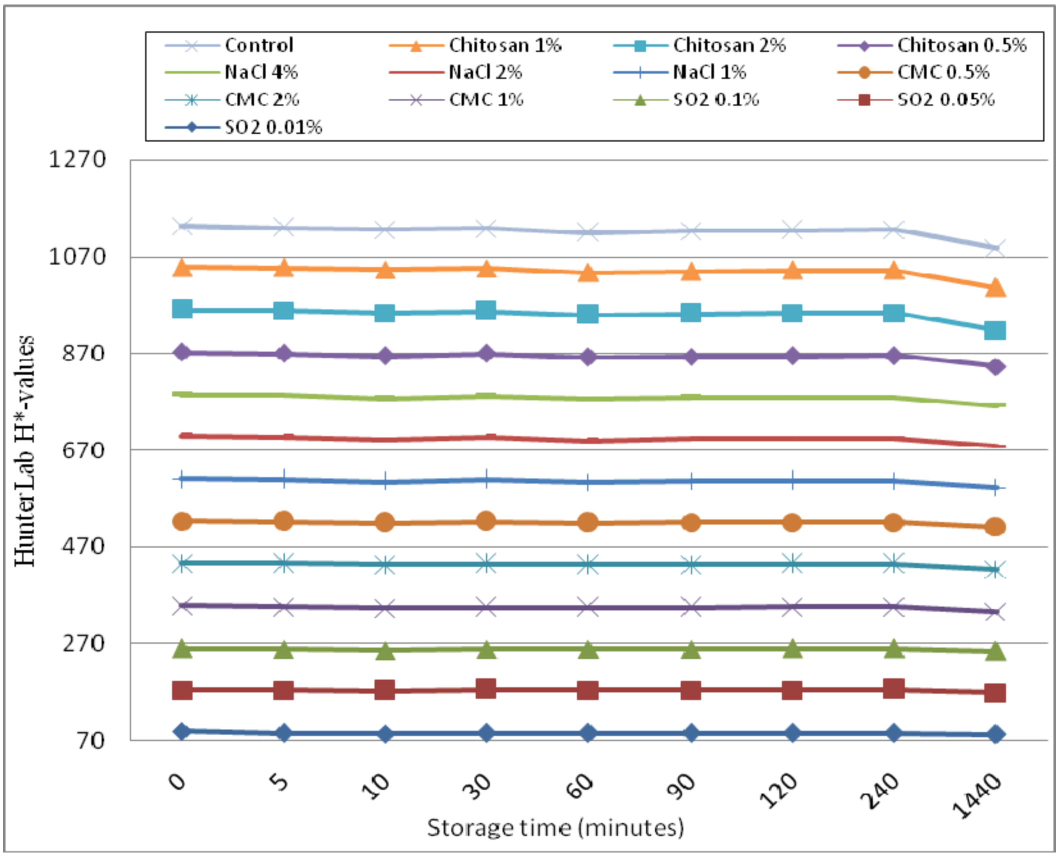

Figure (5b): Effect of chemical treatments on H*-values during storage at room temperature.

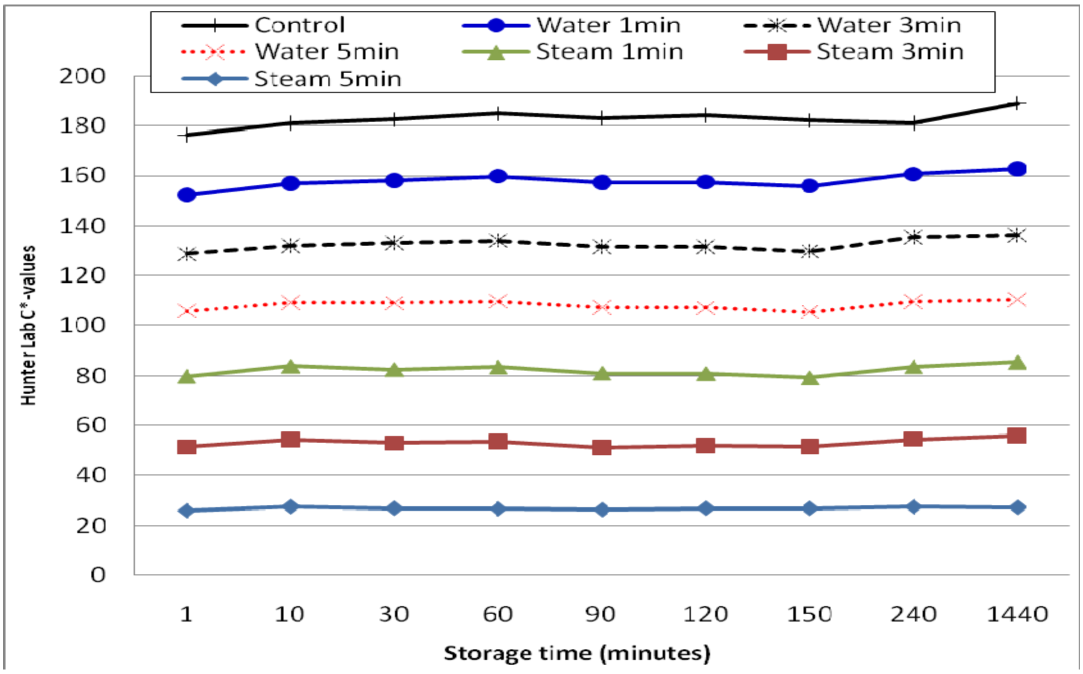

Figure (6 a): Effect of thermal pretreatments on C *-values during storage at room temperature in fresh eggplant rings.

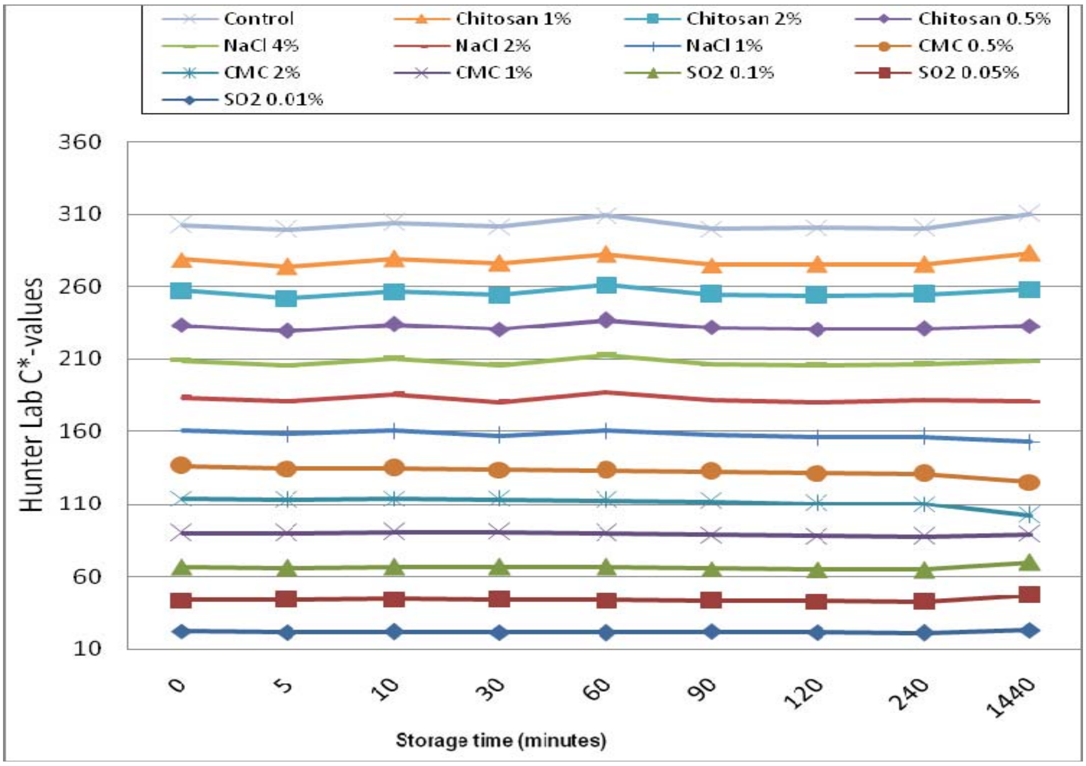

Figure (6b): Effect of chemical treatments on C*-values during storage at room temperature.

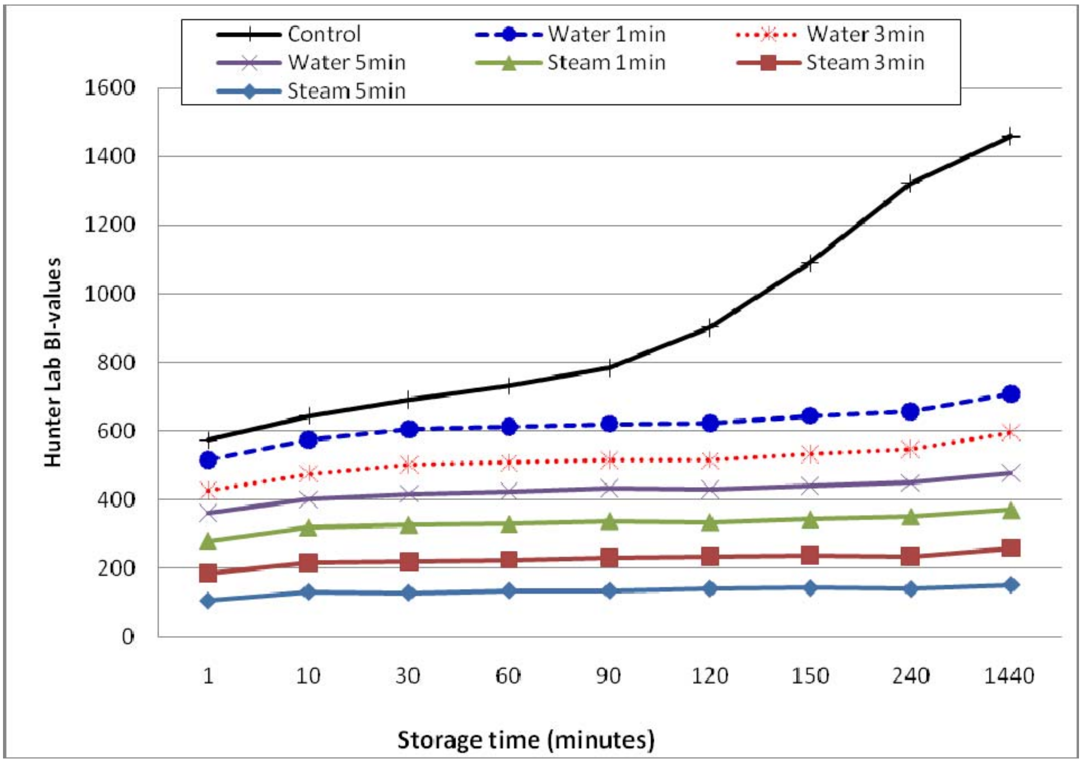

Figure (7 a): Effect of thermal pretreatments on BI-values during storage at room temperature in fresh eggplant rings.

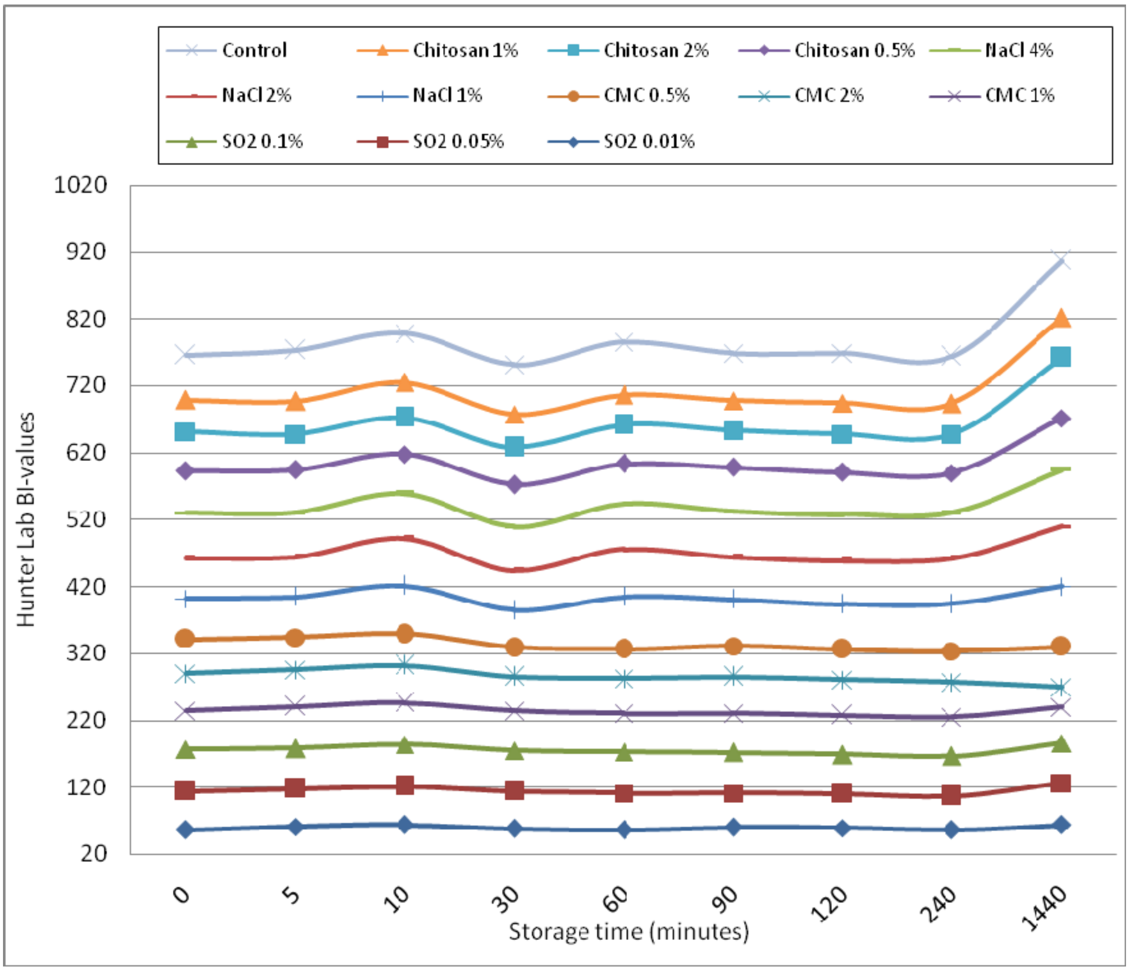

Figure (7b): Effect of chemical treatments on BI*-values during storage at room temperature.

4. Conclusion:

Using SO_2 or steam blanching pretreatments as a pretreatment for eggplant rings were able to optimize the quality of eggplant rings during storage at room temperature for 24 hrs. Frying eggplant rings at 180°C/4 min for the previous pretreatments of SO_2, chitosan and steam blanching were able to optimize the quality of eggplant rings regarding to L*, a*, C*, BI, ΔE-values, non-enzymatic browning (A_{420} nm) and sensory evaluation.

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References:

Beaulieu, M., Beliveau, G.M., Lacroix, M., 1999. Dose rate effect of irradiation on phenolic compounds, polyphenol oxidase, and browning of mushrooms (Agaricus bisporous). J. Agric. Food Chem. 47, 2537–2543.

Bertolini R., Campanone L., Garcia M. and Zaritzky N. (2008) Comparison of the deep frying process in coated and uncoated dough systems. J. of Food Engineering 84, 383-393.

Birk, E.; Mannheim, C. and Saguy, I. (1998). A rapid method to monitor quality of apple juice during thermal processing. Lebensm.-Wiss.u.-Technol., 31:.612-616.

Cantwell, M. & Suslow, T. V. (1999). Indicadores basicos del manejo poscosecha deberenjena, Departamento de productos vegetales, Universidad de California, Davis, USA. Available: www.ucdavis. edu.

Cantwell, M. and Suslow, T.V., 2009. Eggplant: recommendations for maintaining postharvest quality. http://postharvest.ucdavis.edu/Produce/ProduceFacts/Veg /eggplant.shtml.

Concellń, A., A˜non, M.C., Chaves, A.R., 2004. Characterization and changes in polyphenol oxidase from eggplant fruit (Solanum melongena L.) during storage at low temperature. Food Chem. 88, 17–24.

Concellń, A., A˜non, M.C., Chaves, A.R., 2007. Effect of low temperature storage on physical and physiological characteristics of eggplant fruit (Solanum melongena L.). LWT 40, 389–396.

Das, J. R., Bhat, S. G., & Gowda, L. R. (1997). Puri.cation and characterization of a polyphenol oxidase from the Kew cultivar of Indian pineapple fruit. Journal of Agricultural Chemistry, 45, 2031–2035.

FAOSTAT (Food and Agriculture Organization of the United Nations). Accessed Aug. (2009). http://faostat.fao.org.

Garcĭa-Carmona, F., Valero, E., & Cabanes, J. (1988). E.ect of Lproline on mushroom tyrosinase. Phytochemistry, 27, 1961–1964.

Garcĭa, M. A., Ferrero, C., Be´rtola, N., Martino, M., & Zaritzky, N. (2002). Edible coatings from cellulose derivatives to reduce oil uptake in fried products. Innovative Food Science and Emerging Technologies, 3, 391–397.

Gonulalan, Z., Kose, A. & Yetim, H. (2003). Effects of liquid smoke on quality characteristics of turkish standard smoked beef tongue. Meat Science, 66, 165–170.

Hunter, R.S. (1975). Scales for measurements of colour differences. In: Measurement for Appearance, J. Wiley (Ed.) p 133. Interscience, New York.

Janovitz-Klapp, A.H., Richard, F.C., Goupy, P.M. & Nicolas, J. (1990). Inhibition studies on apple polyphenoloxiadase. Journal of Agriculture Food Chemistry, 38, 926–931.

Monsalve-Gonzalez A., B. Gustavo, R. Cavalieri, A. McEvily and I. Rhada, (1993) "Control of browning during storage of apple slices preserved by combined methods. 4-hexylresorcinol as anti-browning agent," J. Food Science. 58, 4, 797 - 800, 826.

Ozoglu, H. & Bayindirh, A. (2002). Inhibition of enzymatic browning in cloudy apple juice with selected anti-browning agents. Food Control, 13, 213–221.

Perez, F. & Albisu, M. (2002). Brining time and smoking influences on acceptability of idiazabal cheese. Journal of Food Quality, 25, 51–62.

Prohens, J., Rodrnguez-Burruezo, A., Raigń, M.D., Nuez, F., 2007. Total phenolic concentration and browning susceptibility in a collection of different varietal types and hybrids of eggplant: implications for breeding for higher nutritional quality and reduced browning. J. Am. Soc. Hort. Sci. 132, 638–646.

Richard J. and Gouri B. (1987). Statistics "Principles and Methods". Pp.403 – 427, 3rd eds. John Wiles and Sons, New York.

Sapers G. and Douglas F. (1987). Measurement of enzymatic browning at cut surfaces and in juice of raw apple and pear fruits. Journal of Food Science, 52, 1258-1262, 1285.

Stamp J. and Labuza T. (1983). Kinetics of the Maillard reaction between Aspartame and Glucose in solution at high temperatures. J. of Food Sci. 48: 543-544,547.

Va´mos-Vigya´zo´, L. (1981). Polyphenol oxidase and peroxidase in fruits and vegetables. Critical Reviews in Food Science and Nutrition, 15, 49–127.

Vickers JE, Grof CPL, Bonnett GD, Jackson PA, Morgan TE (2005) Effects of tissue culture, biolistic transformation, and introduction of PPO and SPS gene constructs on performance of sugarcane clones in the field. Australian Journal of Agricultural Research 56, 57–68.

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