WFL Publisher
Science and Technology

Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.11 (2): 142-148. 2013

www.world-food.net

Effects of Arabic gum coating on physico-chemical properties and kinetics of color change in tomato (*Solanum lycopersicum* L.) fruits during storage

Fahad Al-Juhaimi, Kashif Ghafoor * and Elfadil E. Babiker

*Department of Food Science and Nutrition, College of Food and Agricultural Sciences, King Saud University, P. O. Box 2460, Riyadh 11451, Kingdom of Saudi Arabia. *e-mail: kashif_ft@hotmail.com*

Received 3 February 2013, accepted 26 April 2013.

Abstract

Tomato (*Solanum lycopersicum* L.) is an important food commodity from nutritional and commercial point of view, however, freshly harvested tomato has shorter shelf life in the market. Tomato coated with gum Arabic (5-20% solution) was evaluated during 16 day storage at 24±1°C. Firmness of uncoated fruits was significantly ($p \leq 0.05$) lower and weight loss higher. Uncoated fruits had higher total solids, lower acidity and uneven pH. *L* and *b* values decreased while *a* value increased. Hue angle of fruits decreased and total color change increased, significantly. Chroma and browning index increased slightly while the color index increased significantly. The kinetic models of color change were dependent on gum concentration. Coated fruits had good sensory acceptability till 8-12 days. Tomato strategies to preserve its physico-chemical and sensorial characteristics have significance for grower, processor and seller. We observed that gum Arabic coating effectively preserved different quality attributes of tomato fruits at even elevated storage temperature for longer time.

Key words: Tomato, gum Arabic, edible coating, physico-chemical properties, color kinetics.

Introduction

The research for development of technologies to ensure the delivery of high-quality fruits and vegetables is essential and significant for grower, processor, retailer and consumer [1]. Tomato (*Solanum lycopersicum* L.) is among the most consumed fruits in the world and as such could be considered as an important source of dietary antioxidants [2]. Tomato, being a climacteric fruit, has a relatively short postharvest life since many physico-chemical changes causing quality loss take place at this stage, storage life being limited by several factors including transpiration, postharvest diseases, increased ripening and senescence [3]. The main factor associated with tomato postharvest shelf-life, particularly in tropical regions where the temperature is high, is increased respiration which results in faster fruit ripening and deterioration of fruit quality [4]. The application of edible coatings can improve the physical strength of food products, reduce particle clustering, and improve visual and tactile features on product surfaces [5]. The coating can also protect food products from moisture migration, microbial growth, light-induced chemical changes, and oxidation of nutrients and acts as a carrier of active substances such as antioxidants, antimicrobials, colors and flavors[6]. Gum Arabic or gum acacia is dried gummy exudates from the stems or branches of *Acacia* species. It is the least viscous and most soluble among hydrocolloids and is used extensively in the industrial sector due to its emulsification, film forming and encapsulation properties [7]. A study by Zapata *et al.* [3] showed that alginate or zein as edible coatings for tomato fruit showed beneficial effects for retarding the ripening process and changes triggered by the plant hormones, such as color change and loss of firmness. The objective of this study was to investigate the effects of application of gum Arabic edible surface coating on fruit firmness, weight loss, pH, acidity, total soluble solids, color kinetics and sensory characteristics of mature-red tomato fruits during storage for 16 days at 24 ± 1°C.

Materials and Methods

Plant materials and treatments: Fresh and and ripe tomato (*Solanum lycopersicum* L. var. Grandella) with a color index of 29.616 to 28.768 was obtained from a demonstration farm in Riyadh, Saudi Arabia, and experiments were carried out on the same day. Food grade gum Arabic powder was obtained from local market. Selected fruits had good shape and homogenous size, color and maturity. Fruits were washed with a solution of sodium hypochlorite (0.05%) for 3 min and air-dried at room temperature. In order to prepare coating solutions of 5, 10, 15 and 20% (w/v); 5, 10, 15 and 20 g of gum Arabic powder was dissolved in 100 ml distilled water. The solutions were stirred at 40°C for 60 min on a hot plate magnetic stirrer. After cooling to 20°C, glycerol monostearate (1%) was added as a plasticizer to improve the strength and flexibility of the coating solutions. Fruits were dipped in each type of coating solution or distilled water (control) for 3 min. The coatings were applied uniformly on the whole fruit surface and dried at room temperature. A dry layer with plastic texture when touched with hand and the general appearance were used as criteria to determine the end of drying. The thickness of coats

was measured with a micrometer (Mitutoyo, Kanagawa, Japan) to be around 0.01 mm at four locations; average values were (5%: 0.011 ± 0.001 mm; 10%: 0.013 ± 0.001 mm; 15%: 0.016 ± 0.002 mm; 20% 0.021 ± 0.001 mm). Fruits were then packed in perforated plastic bags and stored at 24±1°C and 35-40% RH for 16 days. The data were recorded at 0 day followed by 4 days intervals. All chemicals used in this study were of analytical grade and purchased from Sigma-Aldrich Chemie GmbH, Switzerland.

Fruit firmness measurement: Five tomato fruits from each treatment were analyzed for firmness using Texture Analyzer (Model: TA HDi, Stable Micro Systems, HD3128, Surrey, UK) equipped with a 7.9 mm cylindrical probe having flat surface interfaced with a computer. The acquisition rate was 200 PPS and height was 100 mm. The distance and temperature were 5 mm and 24±1°C, respectively. Force (N) readings were recorded at 2% constant deformation on the circumference of each fruit from coated and uncoated lots.

Determination of weight loss percentage: Samples from coated and uncoated tomato fruits were weighed at 0 day and each storage interval at room temperature and the same sample of fruits from each treatment were used for weighing at each observation day. The difference between initial and final fruit weight was considered as total weight loss during that storage interval and calculated as percentages on a fresh weight basis.

Determination of soluble solids, titratable acidity and pH: Fruits from each treatment were ground in a blender and juice was used to determine total soluble solids (TSS) using a digital refractometer (Model: Abbe Mark II, Cambridge Instrument, INC. Buffalo, NY, USA). The machine was standardized using purified water before readings were taken. Titratable acidity (TA) was determined as a percentage using previously described method [8]. The pH was measured using a pH meter (Model: pH meter 240, Corning Scientific Products, NY, USA).

Color measurements: During storage, tomato fruits were taken at specified time intervals for color measurements (*L*, *a* and *b* values) which were measured with a HunterLab colorimeter (Hunter Associates Laboratory, Inc., VA, USA). The instrument (45°/0° geometry, D 65 optical sensor, 10° observer) was calibrated using white and black reference tiles through the tri-stimulus values *X*, *Y* and *Z*, taking as standards the values of white background tile. Tomato fruits were scanned for color at three different locations to determine the average *L*, *a* and *b* values during colorimetric measurements. In addition, the total color change (ΔE) (Eq. 1), chroma (Eq. 2), hue angle (Eq. 3), browning index (Eq. 4) and color index (Eq. 5) were calculated from the Hunter *L*, *a* and *b* scale and used to describe the color change during storage.

$$\Delta E = [(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2]^{0.5} \quad (1)$$

$$Chroma = (a^2 + b^2)^2 \quad (2)$$

$$\text{Hue angle} = \tan^{-1}(b/a)^2 \quad (3)$$

where x = A + 1.75L/ 5.645L + a - 3.012b

$$Browning\ index = \frac{100\,(x - 0.31)}{0.17} \quad (4)$$

where L_0, a_0, b_0 are the initial color measurements of raw fruits and

$$Color\ index = \frac{21.6a - 7.5b}{La} \times 100 \quad (5)$$

L_t *a*, *b* are the color measurements at pre-specified time.

Kinetics models for color change: In order to determine the color change of tomato as a function of storage time, zero-order or first-order kinetic models [9] were determined according to Eq. 6 and Eq. 7, respectively, as under:

$$C_t = C_0 + K_0.t \quad (6)$$

$$C_t = C_{0\,exp}(\pm K_1.t) \quad (7)$$

where C_0 is the initial value of color and C_t is the color value at a pre-specified time, t. The order of reaction for the color parameters during tomato fruit storage was determined by the adjustment of experimental data to the integrated Eqs 6 and 7 using linear regression analysis. In each case, the best fit was selected and the kinetic rate constant at each process was determined.

Sensory evaluation: The sensory evaluation was carried out using 5-hedonic scale, by a semi-trained panel. Ten panelists were selected from the department staff that passed olfactory and taste sensitivities as well as verbal abilities and creativity. The panelists were asked to complete a questionnaire after testing color, taste, tenderness, appearance and overall acceptability of coded samples of tomato fruits weather untreated or surface coated with gum Arabic at selected intervals of storage. They were scored on a scale of 1–5 (1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent).

Statistical analysis: Measurements were carried out in triplicates and data was expressed as mean ± standard deviation (SD). Data was evaluated using analysis of variance (ANOVA) and comparisons of means for treatments were done by using Duncan's multiple range tests. Significance was defined at $P < 0.05$. Statistical analysis was done using Microsoft Excel (MS Office professional Edition 2007, Microsoft Corporation, Redmond, USA) and Sigma Plot 10 (Systat Software Inc. San Jose, CA, USA) software.

Results and Discussion

Effects of gum coating on fruit firmness and weight loss: The firmness of the fruits was significantly ($P < 0.05$) reduced with storage time for both surface-coated and control fruits (Fig. 1A). At the end of the storage period, control fruits had lower firmness values than that of the coated ones. The maximum firmness was maintained by the 20% gum Arabic surface coating up to day 12 and thereafter no significant differences were observed among coated tomatoes. Fruit softening results from cell structure deterioration and changes in composition of cellular material and cell wall [10]. This is a biochemical process involving pectin and starch hydrolysis due to enzymes including wall hydrolases. De-polymerization (shortening of chain length of pectin substances) occurs with an increase in pectinesterase and polygalacturonase activities during fruit ripening [11]. Low levels of O_2 and high levels of CO_2 may reduce the action of these enzymes allowing the retention of the firmness during storage [12]. Respiration rates of

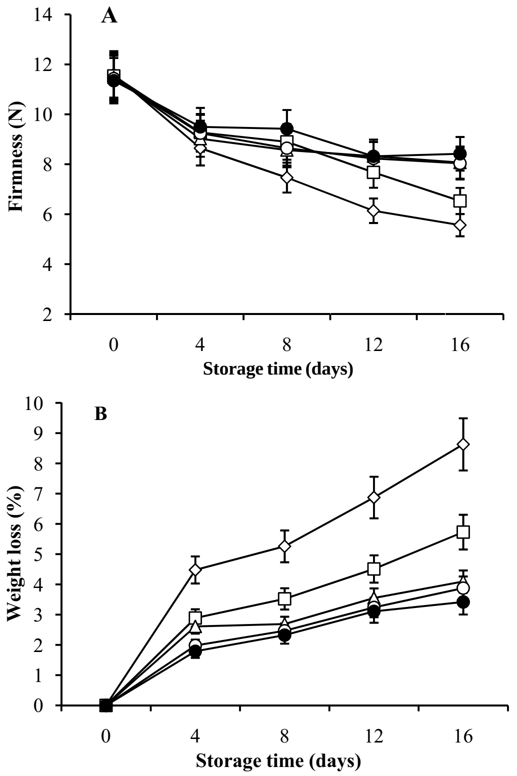

Figure 1. Effect of surface coating with gum Arabic of different concentrations on firmness (A) and weight loss (B) of tomato fruits during storage (16 days at 24 ± °C). Control (◊), 5% (□), 10% (Δ), 15% (○), 20% (●).

coated tomatoes may also be reduced which might be a cause of delaying ripening and this helps in maintaining the storage stability of fruit firmness. Fruit which were coated with 15 and 20% gum Arabic in our study had significantly ($P < 0.05$) lower loss of weight during storage than the control (Fig. 1B) and the weight loss was gradually raised with increased storage duration. The basic mechanism of weight loss from fresh fruit and vegetables is due to vapour pressures at different locations and besides that respiration also results in loss of weight of fruits [13]. The prevention of weight loss was due to the role of gum coating to act as a semi-permeable barrier against O_2, CO_2, moisture and solute movement, which in turn reduced respiration, water loss and rates of oxidation reaction [14]. It can be explained that a thicker coating, such as one made by 20% gum, act as a good barrier to factors causing loss of fruit weight. However, in another study by Park *et al.* [15] it was observed that tomato fruit coated with a too thick corn-zein film resulted in too low O_2 and excessive CO_2 concentrations, which caused ethanol production. They observed an increased loss of weight and primary reason for that was the generation of heat and production of end products from anaerobic fermentation in thickly coated tomato fruits. However, in the present study coating of tomato with 20% gum Arabic solution did not increase the rate of fruit weight loss during storage at 24±1°C, the reason of this being the fact that we used tomato at the red stage of ripening as confirmed by the color index.

Effect of gum coating on total soluble solids, titratable acidity and pH: In general, there was a gradual increase in total soluble solids (TSS) during the complete storage period (Fig. 2A). The TSS was significantly ($P < 0.05$) higher in control samples compared to coated fruit and the marginal increments in TSS of coated fruits were constant except for those coated with 5% gum Arabic. The lowest TSS at the end of the storage period was recorded in fruit coated with 20% gum Arabic, and showed that the coatings provided an excellent semi-permeable film around the fruit, modifying the internal atmosphere by reducing O_2 and/or elevating CO_2 and suppressing ethylene production. The results obtained agree with other reports [3, 16] which concluded that the TSS was significantly higher ($P < 0.05$) in control compared to coated fruit and the reduction in TSS in coated fruit was directly proportional to the concentration of the coating. Decreased respiration rates also slow down the synthesis and use of metabolites resulting in lower TSS [11]. It has been reported that fresh samples (before storage) of tomato tended to show a greater %TSS than stored tomatoes, regardless of the treatment imposed. Further they reported that TSS reduction with storage is generally related to sugar-acid metabolism. A higher level of CO_2 in modified atmosphere packaging was reported to restrict the reduction in TSS of cherry tomatoes with storage [17]. The titratable acidity (TA) values of surface coated and uncoated fruit during storage decreased with storage time (Fig. 2B) and the decline rate was significantly ($P < 0.05$) higher for the control fruits compared to surface coated ones. The low level of TA in the control fruits compared to coated fruits suggests that gum coating delayed ripening by providing a semi-permeable film around the fruit. It was observed that the titratable acidity (TA) values of coated and uncoated tomato fruits during storage decreased with storage time and the value was significantly higher ($P < 0.05$) in gum Arabic treated fruits compared to the control. The increase in TA was directly proportional to the gum Arabic concentration. Since organic acids, such as malic or citric acid, are primary substrates for respiration, a reduction in acidity is expected in highly respiring fruit [8]. It is also considered that coatings reduce the rate of

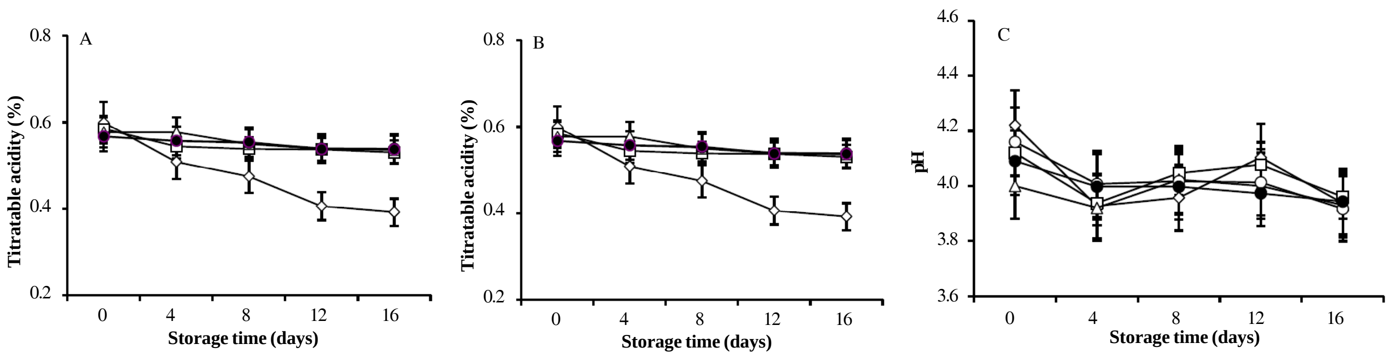

Figure 2. Effect of surface coating with gum Arabic of different concentrations on total soluble solids (A) titratable acidity (B) and pH (C) of tomato fruits during storage (16 days at 24 ± °C). Control (◊), 5% (□), 10% (Δ), 15% (○), 20% (●).

respiration and may therefore delay the utilization of organic acids [11]. The pH (Fig. 2C) of coated and uncoated fruits was fluctuated during the storage period. However, at the end of the storage period the final values of pH for all samples were slightly lower than that of the initial period. The results obtained for the pH were consistent with those reported by Mejia-Torres *et al.* [18].

Effects of gum coating on color of tomato during storage: The initial color showed positive *a* values, indicating redness of the fruits, for the control and coated fruits throughout the storage period at 24 ± 1°C (Fig. 3A). The final *a* values of the all the samples were significantly ($P < 0.05$) higher than the initial ones. Surface coating of the fruits with gum significantly retained the redness values with increase in gum percent and also with the storage time at 24 ± 1°C. A decrease in the *b* values (Fig. 3B) of surface coated as well as the control fruits was observed during storage at 24 ± 1°C. The loss of *b* values indicates that the yellowness of samples which was significantly lower in coated fruits in comparison to control. The less change in *b* values was probably due to retained fruit pigments as it was reported that reduction in *b* value may be due to decomposition of chlorophyll and carotenoid pigments (Weemaes *et al.* [19]), non-enzymatic Maillard browning and formation of brown pigments [20]. *L* values of uncoated fruits was decreased with the storage time and reached maximum value at day 16 at 24 ± 1°C (Fig. 3C). It has been stated that the change in the brightness of fruits can be taken as an indicator of browning of fruits [21, 22]. Surface coating of the fruits with gum Arabic reduced the rate of loss in brightness of the fruits by reducing the rate of reduction in *L* values and it was observed that as the concentration of gum increased, the rate of reduction in *L* value decreased. The results indicated that gum retained the brightness of the fruits by giving a shiny appearance.

The hue angle significantly ($P < 0.05$) decreased with the storage time for the control and surfaced coated samples indicating that tomato fruits gained deep red color with increase in storage time at 24 ± 1°C (Fig. 4A). The rate of reduction in hue angle of fruits coated with 15 and 20% gum was low compared to that of the control samples. The results indicated that surface coating of the fruits retains the characteristics color of tomato. Chroma of both control and surface coated samples was significantly decreased during the first four days of storage at 24 ± 1°C (Fig. 4B) and thereafter started to increase. The rate of increment was significantly higher in surface coated fruits compared to the control ones. During storage, the final chroma increased with increase in gum concentration, thus indicating retention of redness in tomato fruits. Overall, the total color change (ΔE) in the control fruits was significantly higher than that of surface coated fruits (Fig. 4C). Variations in ΔE were observed even among gum concentrations, with 20% resulting in a significantly low rate of increase in ΔE. The results obtained indicated that surface coating of tomato fruits with 20% gum retained the original redness to a more extent than control fruits even after 16 days of storage.

The color index of the control and surface coated fruits was increased with the storage time. The rate of increment depended on gum concentration or the coat thickness (Fig. 5A) with 20% gum resulted in a lower rate of increment in color index. The significant increment in the color index may be an indication of the development of deep red color in tomato. The results showed that surface coating of tomato fruits reduced the rate of increment in color index and maintained the original color of the fruits. The browning index of the control and surface coated fruits was increased with the storage period. The rate of increment depends on gum concentration or the coat thickness (Fig. 5B). It has been observed that 15 and 20% surface coating resulted in a lower rate of reduction in increment in browning index. The significant ($P < 0.05$) increment in the browning index may be due to well-known

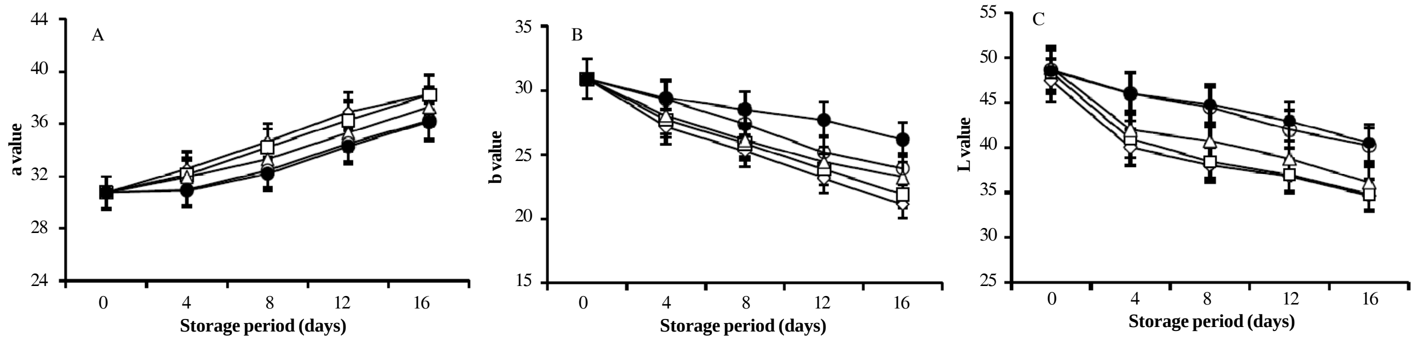

Figure 3. Effect of surface coating with gum Arabic of different concentrations on a (A), b (B) and L (C) values of tomato fruits during storage (16 days at 24 ± °C). Control (◇), 5% (□), 10% (Δ), 15% (○), 20% (•).

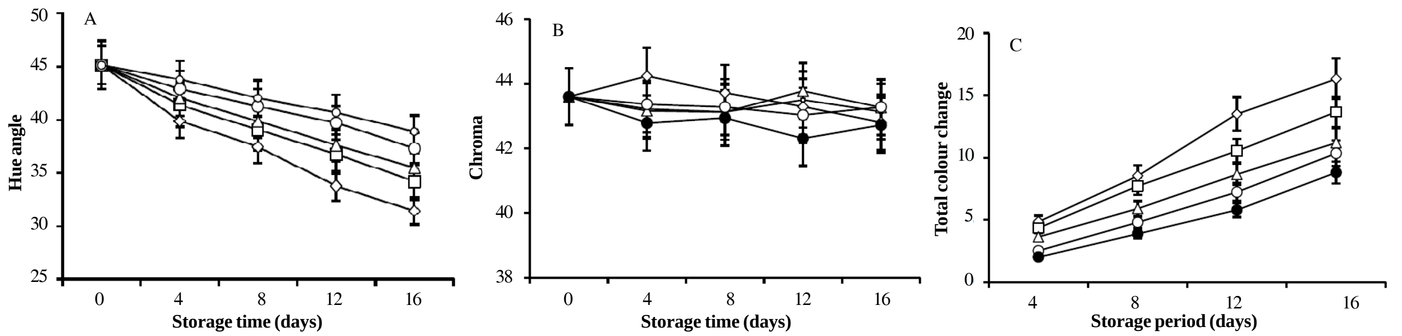

Figure 4. Effect of surface coating with gum Arabic of different concentrations on hue angle (A), chroma (B) and total color change ΔE (C) of tomato fruits during storage (16 days at 24 ± °C). Control (◇), 5% (□), 10% (Δ), 15% (○), 20% (•).

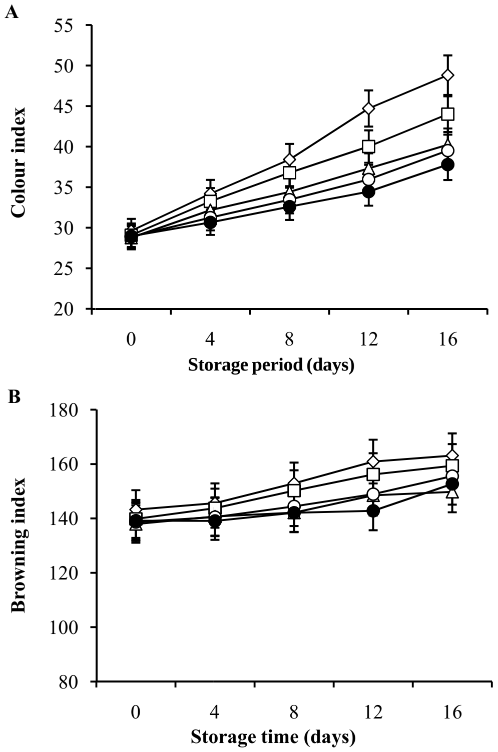

Figure 5. Effect of surface coating with gum Arabic of different concentrations on color index (A) and browning index (B) of tomato fruits during storage (16 days at 24 ± °C). Control (◇), 5% (□), 10% (Δ), 15% (○), 20% (•).

Maillard reaction (enzymatic and non-enzymatic browning) which results in the formation of colored melanoidins. The results showed that surface coating of tomato fruits reduced the rate of increment in browning index and therefore retarding Maillard reaction. It is possible that gum provided a thick barrier against gas exchange between inner and outer environments, and therefore delayed the physiological changes of the fruit during storage. Color is an important criterion of quality and consumer acceptability, especially with respect to fresh vegetables [23]. Therefore, from these results, it can be understood that some modifications would have occurred in the optical properties of uncoated tomato fruits (changes due to oxidation processes or other chemical reactions) during storage.

Mathematical modeling of color change kinetics: For the mathematical modeling of color change of tomato fruits, zero-order and first-order kinetic models were used. The estimated kinetic parameters of these models and corresponding values of correlation coefficients (R^2) of *a, b* and *L* during storage are shown in Table 1. The kinetic of color parameters of tomato coated with gum and stored for 16 days at 24 ± 1°C was greatly affected by the thickness of the coat i.e. the percent of gum applied. For *a* values, the correlation coefficients (R^2) during storage period at 24±1°C of the zero-order model ranged from 0.807 to 0.964 and that of the first-order model ranged from 0.700 to 0.948 depending on the concentration of gum. Changes in *a* values of surface coated as well as the control samples during storage for 16 days could be adequately characterized by the zero-order model. The results imply that with an increase in storage time, the rate of color change of the fruits was increased with time. The results obtained were in agreement with that obtained for kiwifruits [20], okra [21] and spinach[22]. The correlation coefficients (R^2) of *b* values of the zero-order model ranged from 0.591 to 0.960 and that of the first-order model ranged from 0.664 to 0.954 of surface coated tomato during storage at 24 ±1°C. As shown in Table 1 the color change during storage of the control sample and that of surface coated with 5, 10 and 15% gum followed a zero-order model while that of surface coated with 20% followed a first-order model. The results obtained showed a variation in color change between coated and uncoated fruits and within coated ones which could be due to differences in thickness of the coat applied. The correlation coefficients (R^2) of *L* values of the zero-order model ranged from 0.345 to 0.637 and that of the first-order model ranged from 0.273 to 0.884 of surface coated tomato during storage at 24±1°C. The color change during storage of the control sample and that of surface coated with 5 and 10% gum followed first-order model while that of surface coated with 15 and 20% followed a zero-order model. The results showed that the correlation coefficient of *L* values is very weak compared to *a* and *b* values. Table 1 also represents the statistical values of zero- and first-order models of hue angle, chroma, browning index and color index of surface coated tomato fruits stored at 24±1°C for different period of time. The results showed that the calculated values of hue angle of uncoated and surface coated with 5 and 10% gum fruits stored at 24±1°C could be adequately described using a zero-order model while that coated with 15 and 20% gum followed a first-order model with high values for the corresponding of coefficients of correlation (R^2). The data obtained for chroma of uncoated and surface coated fruits stored at 24±1°C followed a zero-order kinetic model. These results obtained disagree with reports [21, 22] for okra and spinach, where it has been stated that the first-order kinetic model was better suited for describing the kinetics of chroma and a zero-order kinetic model for hue angle. The results showed that the calculated values of browning index of uncoated and surface coated with 5, 10 and 20% gum fruits stored at 24±1°C could be adequately described using a zero-order model while that coated with 15% gum followed a first-order model with high values for the corresponding of coefficients of correlation (R^2). The calculated values of color index of uncoated and surface coated with 5, 10 and 20% gum fruits stored at 24± 1°C could be adequately described using a first-order model while that coated with 15% gum followed a zero-order model. The zero-order and first-order kinetic models were used to estimate the color change kinetics of tomato fruits at any time during storage at 24±1°C. The results showed that the thickness of the coat determined the type of model for color change during storage of tomato at 24±1°C. Color changes of such fruits are of interest as these changes have a direct impact on consumer acceptability.

Effect of gum coating on sensory characteristics of tomato during storage: The sensory scores of quality attributes (color, taste, tenderness, appearance and overall acceptability) of uncoated fruits significantly ($P < 0.05$) decreased with the storage time (Table 2). However, surface coating of the fruits significantly retained the sensory attributes by obtaining more panelists' score. The results showed that as the surface coating thickness increased the quality of tomato increased, due to the fact that surface coating reduced losses in water, firmness, color and other constituents of the fruit. It seems from the data that coated fruits had good acceptability till 8-12 days. Similar results were obtained in our

Table 1. The statistical values of zero- and first-order (Kmin^{-1}) models of *a*, *b* , *L* , hue angle, chroma, browning index and color index of tomato coated with gum Arabic (5-20% solution) during storage for 0-16 days at 24 ± 1°C.

Gum percent	*a*		*b*		*L*		Hue angle		Chroma		Browning index		Color index	
	Zero-order	First-order	Zero-order	First-order	Zero-order	First-order	Zero-order	First-order	Zero-order	First-order	Zero-order	First-order	Zero-order	First-order
0	0.8440	0.8018	0.8286	0.7257	0.3451	0.86	0.8895	0.58075	0.8319	0.830829	0.8986	0.896977	0.8544	0.882136
5	0.8073	0.6607	0.8332	0.7138	0.3486	0.8839	0.8969	0.172725	0.8829	0.881094	0.9159	0.913513	0.8729	0.902435
10	0.9640	0.9475	0.9599	0.9541	0.4395	0.7563	0.8723	0.142714	0.9917	0.991543	0.6098	0.630573	0.7148	0.803763
15	0.9235	0.9019	0.7320	0.6689	0.6056	0.3268	0.8315	0.899062	0.9866	0.986886	0.1671	0.65800	0.8373	0.333713
20	0.9502	0.9338	0.5908	0.6640	0.637	0.2728	0.9996	0.999069	0.9153	0.913344	0.7349	0.700419	0.3317	0.90000

Table 2. Effects of gum Arabic coating (5-20% solution) on sensory characteristics of tomato fruits during storage for 0-16 days storage at 24 ± 1°C.

Gum	Color					Taste					Tenderness					Appearance					Overall acceptability				
%	0	4	8	12	16	0	4	8	12	16	0	4	8	12	16	0	4	8	12	16	0	4	8	12	16
0	4.81	3.86	3.77	3.00	1.31	4.22	3.37	3.26	2.74	1.58	4.30	3.66	3.65	3.17	1.33	4.31	3.86	3.81	3.10	2.31	4.11	3.67	3.86	3.00	2.24
	±0.33	±0.12	±0.26	±0.23	±0.11	±0.70	±0.73	±0.75	±0.82	±0.31	±0.16	±0.27	±0.33	±0.70	±0.13	±0.23	±0.20	±0.21	±0.61	±0.30	±0.53	±0.34	±0.65	±0.87	±0.23
5	4.83	4.25	4.12	3.86	3.11.	4.17	4.03	3.98	2.83	2.61	4.45	4.23	4.10	3.96	2.91	4.51	4.27	4.16	3.93	2.97	4.17	4.07	3.96	3.70	2.99
	±0.26	±0.61	±0.45	±0.15	±0.36	±0.31	±0.54	±0.28	±0.35	±0.16	±0.26	±0.17	±0.37	±0.66	±0.46	±0.76	±0.31	±0.26	±0.51	±0.36	±0.66	±0.58	±0.49	±0.99	±0.76
10	4.79	4.05	3.86	3.60	2.93	4.32	3.99	3.88	3.36	2.63	4.53	4.30	4.03	3.86	2.93	4.53	418	4.08	3.86	3.00	4.43	4.17	3.95	3.80	3.83
	±0.72	±0.25	±0.23	±0.69	±0.22	±0.19	±0.51	±0.63	±0.42	±0.12	±0.32	±0.60	±0.28	±0.17	±0.32	±0.82	±0.23	±0.43	±0.71	±0.32	±0.52	±0.47	±0.21	±0.37	±0.32
15	4.67	4.25	4.00	3.86	2.97	4.37	3.83	3.80	3.26	2.57	4.67	4.39	4.20	3.93	3.17	4.67	4.23	4.10	3.93	2.97	429	4.13	3.96	3.70	3.79
	±0.31	±0.26	±0.52	±0.34	±0.31	±0.43	±0.52	±0.13	±0.25	±0.21	±0.21	±0.56	±0.48	±0.11	±0.21	±0.31	±0.51	±0.21	±0.40	±0.71	±0.61	±0.56	±0.60	±0.70	±0.51
20	4.77	3.97	3.96	3.79	2.81	4.20	3.88	3.81	3.46	2.54	4.85	4.37	4.09	3.86	3.18	4.45	4.30	4.15	3.96	3.08	4.25	4.09	3.86	3.63	3.67
	±0.42	±0.28	±0.56	±0.74	±0.52	±0.28	±0.16	±0.48	±0.31	±0.42	±0.70	±0.34	±0.50	±0.36	±0.31	±0.72	±0.52	±0.39	±0.22	±0.72	±0.82	±0.49	±0.24	±0.14	±0.25

Values are means ± standard deviations, *n* = 10.

previous study [8] where gum coating to tomato fruit resulted in a shelf life of around 16 days while stored at 10 °C

Conclusions

Our study showed that surface coating of tomato fruit with gum Arabic significantly ($P < 0.05$) delayed undesirable changes in weight, firmness, titratable acidity, soluble solids concentration and color during storage at 24±1°C as compared to uncoated fruit. The coated fruits retained better color quality throughout the storage and preserved more redness (lower *a* values) and lesser yellowness (higher *b* values) and they were brighter and shiny (higher *L* values) than control fruits. The kinetics of change in different color attributes (a, b and L values, hue angle, chroma, browning and color indexes) for coated and control fruits, followed both zero and first order models which also depended on the gum concentration or coat thickness. Considering panelists scores we can conclude that gum Arabic coating can preserve the quality for mature red tomatoes for 8-12 days at nearly room temperature.

Acknowledgements

This project was financially supported by King Saud University, Deanship of Scientific Research, College of Food and Agricultural Sciences, Research Center.

References

[1]Cisneros-Zevallos, L. 2003. The use of controlled postharvest abiotic stresses as a tool for enhancing the nutraceutical content and adding-value of fresh fruits and vegetables. J. Food Sci. **68**:1560–1565.

[2]Lenucci, M. S., Cadinu, D., Taurino, M., Piro, G. and Dalessandro, G. 2006. Antioxidant composition in cherry and high-pigment tomato cultivars. J. Agric. Food Chem. **54**:2606–2613.

[3]Zapata, P. J., Guillén, F., Martínez-Romero, D., Castillo, S., Valero, D. and Serrano, M. 2008. Use of alginate or zein as edible coatings to delay postharvest ripening process and tomaintain tomato (*Solanum lycopersicon* Mill) quality. J. Sci. Food Agric. **88**:1287–1293.

[4]Bailén, G., Guillén, F., Castillo, S., Serrano, M., Valero, D. and Martínez-Remero, D. 2006. Use of activated carbon inside modified atmosphere packages to maintain tomato fruit quality during cold storage. J. Agric. Food Chem. **54**:2229–2235.

[5]Cisneros-Zevallos, L., Saltveit, M. E. and Krochta, J. M. 1997. Hygroscopic coatings control surface white discoloration of peeled (minimally processes) carrots during storage. J. Food Sci. **62**:363–366.

[6]Miller, K. S., Upadhyaya, S. K. and Krochta, J. M. 1998. Permeability of d-limonene in whey protein films. J. Food Sci. **63**:244–247.

[7]Motlagh, S., Ravines, P., Karamallah, K. A. and Ma, Q. 2006. The analysis of Acacia gums using electrophoresis. Food Hydrocolloids **20**:848–854.

[8]Al-Juhaimi, F. 2013. Physicochemical and sensory characteristics of Arabic gum-coated tomato (*Solanum lycopersicum* L.) fruits during storage. J. Food Process. Preserv. DOI: 10.1111/jfpp.12053.

[9]Maskan, A., Kaya, S. and Maskan, M. 2002. Effect of concentration and drying processes on color change of grape juice and leather (pestil). J. Food Eng. **54**:75–80.

[10]Seymour, G. B., Manning, K., Eriksson, E. M., Popovich, A. H. and King, G. J. 2002. Genetic identification and genomic organization of factors affecting fruit texture. J. Experiment. Bot. **53**:2065–2071.

[11]Yaman, O. and Bayoindirli, L. 2002. Effects of an edible coating and cold storage on shelf-life and quality of cherries. Lebensmittel-Wissenschaft und-Technologie **35**:146–150.

[12]Al-Juhaimi, F., Ghafoor, K. and Babiker, E. E. 2012. Effect of gum arabic edible coating on weight loss, firmness and sensory characteristics of cucumber (*Cucumis sativus* L.) fruit during storage.

Pak. J. Bot. **44**:1439-1444.
[13]Pan, J. C. and Bhowmilk, S. R. 1992. Shelf-life of mature green tomatoes stored in controlled atmosphere and high humidity. J. Food Sci. **57**:948–953.
[14]Baldwin, E. A., Burns, J. K., Kazokas, W., Brecht, J. K., Hagenmaier, R. D., Bender, R. J. and Pesis, E. 1999. Effect of two edible coatings with different permeability characteristics on mango (*Mangifera indica* L.) ripening during storage. Postharv. Biol. Technol. **17**:215–226.
[15]Park, H. J., Chinnan, M. S. and Shewfelt, R. L. 2006. Edible coating effects on storage life and quality of tomatoes. J. Food Sci. **59**:568–570.
[16]Ali, A., Maqbool, M., Ramachandran, S. and Alderson, P. G. 2010. Gum arabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato (*Solanum lycopersicum* L.) fruit. Postharv. Biol. Technol. **58**:42–47.
[17]Akbudak, B., Akbudak, N., Seniz, V. and Eris, A. 2006. The effect of harpin treatment on storage of cherry tomato. Acta Horticulturae **712**:237–243.
[18]Mejia-Torres, S., Misael, V., Javier, V., Jose, L. and Jose, C. 2009. Effect of wax application on the quality, lycopene content and chilling injury of tomato fruit. J. Food Qual. **32**:735–746.
[19]Weemaes, C. V., Ooms, L., Indrawati, I., Ludikhuyze, V., Broeck, A., Loey, A. and Hendrickx, M. 1999. Pressure-temperature degradation of green color in broccoli juice. J. Food Sci. **64**:504-508.
[20]Maskan, M. 2000. Kinetics of color change of kiwifruits during hot air and microwave drying. J. Food Eng. **48**:169–175.
[21]Dadalt, G., Apar, D. K. and Ozbek, B. 2007. Color change kinetics of okra undergoing microwave drying. Dry. Technol. **25**:925–936.
[22]Dadalt, G., Demirhan, E. and Ozbek, B. 2007. Color change kinetics of spinach undergoing microwave drying. Dry. Technol. **25**:1713–1723.
[23]Aked, J. 2000. Fruits and vegetables. In Kilcast, D. and Subramaniam, P. (eds). The Stability and Shelf-Life of Food. Woodhead Publishing,Cambridge, pp. 249–278.