Development of chitosan-glucose and chitosan-citric complexes edible coating to improve tomatoes post-harvest quality

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Abstract: The effect of different shrimp chitosan molecular weights as well as shrimp chitosan complexes (chitosan-glucose and chitosan-citric) on the quality characteristics of the stored (at 7°C±2°C and 90% RH) tomato fruits (*Lycopersicum esculentum*) was investigated. Coating tomatoes with high molecular weight chitosan (H.M.C.G) significantly improved firmness and weight loss. The lowest weight loss was found in high molecular weight chitosan-glucose (H.M.C.G) treatment followed by the fruits coated with high molecular weight chitosan (HMC) and then uncoated tomato fruits. Both molecular weights was clear on retarding the total acidity loss especially for stored tomato fruit coated with low molecular weight chitosan, while control tomatoes exhibited a larger reduction ($p \leq 0.05$) in total acidity over storage. Meanwhile, the increasing of cold storage time significantly ($p \geq 0.05$) increased the pH in all uncoated and coated tomatoes. Generally, no significant ($P > 0.05$) difference was observed in pH, titratable acidity and total soluble solids (T.S.S.) as well as sensory attributes among the tomato fruits coated with chitosan, chitosan citric and chitosan glucose. Meanwhile, the fruits coated with low molecular weight chitosan had a higher ($p \geq 0.05$) T.S.S. compared with that coated by the high molecular weight chitosan.

Keywords: chitosan, edible coating, tomatoes, firmness and weight loss

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1 Introduction

Most fresh fruits and vegetables contain from 65%-95% water when harvested. When the harvested produce loses 5% or 10% of its fresh weight, it begins to wilt and soon becomes unusable. To keep water loss from fresh produce as low as possible, it must be kept in a moist atmosphere (Elazar, 2004). Tomato (*Lycopersicume sculentum*) is a warm-season crop; it ranked the highest in a comparison of crops in their contribution of nutrients to the diet. Water comprises 90% of the fresh weight of tomato fruit; and the fruit size is influenced by the availability of water to the plant. The large amount of water also makes the fruit perishable (Jones, 1999). Many researchers have demonstrated that hot water treatment between 35°C and 63°C effectively inhibits ethylene production, delays ripening (Biggs et al., 1988; Lurie and Klein, 1991), and reduces the water loss of fruits during storage (Baloch et al., 2006; Morimoto et al., 2003; Islam et al., 2012).

Edible films and coatings can be used to help in the preservation of fruit and vegetables because they provide a partial barrier to moisture, O_2 and CO_2, also improving mechanical handling properties, carrying additives, avoiding volatiles loss and even contributing to the production of aroma volatiles (Olivas and Barbosa, 2005). This environment friendly technology wraps the

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film closely around the fruit preventing respiration and transpiration, thus slowing down senescence. Studies have shown that these films can be incorporated with nutrients or preservatives and are functional in various ways. With the demand for more natural foods, bio-preservatives are being added to the films making it more wholesome for consumers (Kader, 1992).

Chitosan, a unique polysaccharide derived from deacetylation of chitin has been used in a wide variety of application in the fresh-keeping field owing to its good biocompatibility, biodegradability, antibacterial activity and capacities to form membrane (Chien et al., 2007). Due to its unique physicochemical properties, Chitosans has been successfully used as food wraps, and maintains the quality of postharvest fruits and vegetables fruit (Devlieghere et al., 2004; Marie et al., 2008). Previous studies indicated that chitosans coating had the potential to prolong storage life and control decay of many fruits, such as strawberry, peach, table grape, apple and mango (Chien et al., 2007; Dong et al., 2004; Maria et al., 2008;Romanazzi et al., 2002).

The objective of our research is to develop an edible coat by using of high as well as low molecular weight shrimp waste chitosan combined with citric or glucose as an edible coating for extension of the fresh tomatoes shelf life.

2 Materials and methods

2.1 Materials

Tomatoes (*Lycopersicume sculentum*) were purchased in their turning stage from a local farm. Fruits with uniform size color and free from damage and fungal infection were washed twice in water and then drained.

Shrimp (Caridina babaulti) Shell was purchased from AbouGhalli Company for trading and exporting Alabour market, Egypt. The shell were manually scraped (free of loose tissue), collected and brought to the laboratory in the same day. Whenever, the shell was brought to the laboratory it was frozen immediately (at 12°C) and stored for further analysis.

2.1.1 Chemicals and reagents

Oxalic acids, sodium hydroxide, hydrochloric acid, acetic acid and citric acid were purchased from El-NasrPharmaceutical Chemicals, El-Ameriea, and Cairo, Egypt. Anhydrous glucose was purchased from Sigma Chemical Co., St. Louis, Missouri, USA.

2.2 Methods

2.2.1 Preparation of high molecular weight chitosan

The preparation of chitosan involved the demineralization (DM), deproteinization (DP), decoloration (DC), and deacetylation (DA) steps (No et al. 2003). Shrimp shell was demineralized with 1N HCl for 30 min at ambient temperature with a solid/solvent ratio of 1:15 (w/v). Following the DM step, the demineralized shell was collected on a 100-mesh sieve, washed to neutrality in running tap water, rinsed with distilled water, and filtered to remove excess moisture. The DP step was accomplished by treating the demineralized shell with 3% NaOH for 15 min at 15 psi/121°C and a solid/solvent ratio of 1:10 (w/v). The residue was then washed and filtered as mentioned above. For the DC step, the resulting chitin residue was bleached with 10% sodium hypochlorite solution for five minutes with a solid/solvent ratio of 1:10 (w/v). The bleached chitin was collected, washed as mentioned above, and dried at 60°C for four hours in a forced-air oven. The DA step was achieved by treating chitin under conditions of 15 psi/121°C with 45% NaOH for 30 min and a solid/solvent ratio of 1:10 (w/v). The resulting chitosan was collected, washed as mentioned above, and dried at 60°C for four hours in a forced-air oven.

2.2.2 Preparation of low molecular weight chitosan

One gram of high molecular chitosan was added into 20 mL of 2% acetic acid (v/v) in a water-bath shaker (SHZ-82A, Henfeng Instrument Company, Jintan, China). The conditions were set as follows: H_2O_2 level (5.5%), time (3.5 h) and temperature (42.8°C). After reaction, 10% NaOH was used to adjust the solution to neutrality. The residue was removed by filtration, while two fold volumes of ethanol were added to the filtrate. The crystal of water-soluble chitosan was liberated after incubation at ambient condition overnight and dried in an air oven at 50°C (Du et al., 2009).

2.2.3 Preparation of chitosan glucose complex

High or low molecular weight chitosan solutions (1%) were dissolved in 1% glacial acetic acid. Chitosan-

glucose complex was prepared by autoclaving high or low molecular weight chitosan (1%) and glucose (1%) for 15 min at 121°C and 15psi (Sweetie et al., 2008).

2.2.4 Preparation of chitosan citric complex

Chitosan citric complex (high and low molecular weight) was prepared by dissolving citric acid (600 g L^{-1}) in boiling water. As the acid dissolved, chitosan solutions were added to a final concentration of 1 g (100 mL)$^{-1}$ (Marie et al., 2008).

2.2.5 Fruit coating

Tomato fruit were dipped in the various chitosan solutions (at room temperature 20°C), drained, dried with a hair dryer for no more than 30 min and then stored at 7°C±2°C and 90% relative humidity (RH). Samples were evaluated during storage period; control fruits were packed in the same way as the treated fruit, but without dipping in the chitosan solutions, and then also stored at 7°C±2°C and 90% RH.

2.2.6 Physical and chemical analysis.

2.2.6.1 Determination of molecular weight

The molecular weight of chitosan samples were determined by using an Ubbelohde viscometer at 30°C. The intrinsic viscosities (η) were determined, the solvent was 5% acetic acid and 0.1 M KCl the obtained intrinsic viscosities were used to calculate molecular weight for the prepared samples from the Mark-Houwink-Sakurada relation:

$$\eta = KM^a \quad (1)$$

where, K and a are constants which $K = 8.93 \times 10^{-4}$ and $a = 0.71$ (Chandumpaia et al., 2004).

2.2.6.2 Determination of the deacetylation percent

Chitosan (0.5 g) was dissolved in 25 mL of 0.1 M standard HCl aqueous solution. The solution was then toped up to 100 mL with distilled water and calculated amount of KCl was added to adjust the ionic strength to 0.1 M. The titrant was a solution of 0.05 M NaOH. The pH meter was used for pH measurements under continuous stirring. The titrant was added until the pH value reached 2.00, the standard NaOH was then added stepwise and the pH values of solution were recorded and a curve with two inflection points was obtained. The difference of NaOH solution volumes between these points corresponds to the acid consumed for salificationof the amine groups of chitosan and allows the determination of degree of deacetylation (*DDA*%) of the chitosan. The deacetelation *DA* was calculated from the relation (Broussignac, 1968).

$$DDA\ \% = (1-161Q)/(1+42Q) \quad (2)$$

where, $Q = NDV/m$, DV is the volume of NaOH solution between the two inflection points; N is the concentration of NaOH (0.05 moll^{-1}), and m is the dry weight of chitosan, g.

2.2.6.3 Determining weight loss

Three replicates of fruits were used for each treatment. Every week (four week), a sample of fruits was removed from each treatment. The fruits were weighed regularly todetermine weight loss.

2.2.6.4 Firmness determination

The firmness changes of fresh and stored tomatoes fruits were measured using a Effigy, (Ravenna, Italy) Fruit Firmness Tester (penetrometer) controlling the penetration depth by inserting an appropriate penetrometer tip (2 mm diameter) into the fruit pulp (AmerEssa, 1998). The firmness was measured on three sides and the results were expressed by Newton.

2.2.6.5 Titratable acidity, pH and soluble solids.

The acidity was calculated as the predominate acid (citric acid) as described in AOAC, 2003. Five grams of the homogenized strawberry or tomato pulp was titrated with 0.1 M NaOH. The Titratable acidity (g citric acid/100g of fresh weight) was calculated by the following equation:

$$\text{Acidity}\ \% = \frac{N \times V \times E.W \times 100}{W \times 1000} \quad (3)$$

Where, N = Normality of NaOH; W = Weight of sample, g; V = Volume of NaOH used in Titration, mL; $E.W$ = Weight Equivalent to organic acid.

PH was determined using a pH meter (Jenyway pH meter Model 3510) as described in (AOAC, 2003). Homogenized tomato pulp was used to determine the amount of soluble solids (°Brix) by Abbe - 2WAJ Refractometer (AOAC, 2003).

2.2.7 Sensory evaluation

Ten trained panelists who were graduate students and staff members in the Department of Food Science and Technology, Minoufiya University performed sensory

evaluation of coated tomatoes (after 24 hours of coating process). Selection of panelist's based on participant interest, taste and flavor acuity and ability to understand test procedures. The panelists were asked to evaluate each sample for colour, texture, taste, flavor and overall acceptability.

2.3 Statistical analysis

The data was subjected to analysis of variance (ANOVA) and Duncan multiple comparison test of means using the software XL STAT 2006. The results were used to determine the least significant differences (LSD) amongst treatments at a significance level of 0.05.

3 Results and discussions

3.1 Tomato firmness

Tomato firmness is often the first of many major quality attributes judged by the consumer and is, therefore, extremely important in overall product acceptance. Tomato suffers a rapid loss of firmness during senescence which contributes greatly to its short postharvest life and susceptibility to fungal contamination. Changes in flesh firmness between control and coated fruit samples during four weeks of storage at 7±2°C are shown in Figure 1. Initial firmness values were similar for control and all coated samples. On the second week of storage, uncoated tomatoes began to show a gradual loss of firmness. The firmness of coated tomato also decreased progressively, but on and after the second week of storage firmness values of coated samples was higher compared to the control samples, and then significant differences were noted between high molecular weight chitosan (H.M.C.G) and other chitosan coating treatments for the same period. With regard to coated samples, H.M.C.G chitosan coating was more effective in preventing decrease of fruit firmness than the other treatments at 7±2°C. The retention of firmness with chitosan coating is similar with the result of (Ali et al., 2011), where papayas treated with 2.0% chitosan coating was firmer than the other treatments during cold storage. Fruit, such as tomato and mango, have also been reported to be firmer when treated with chitosan (Kim et al., 1999; Zhu et al., 2008). In this study, fruit softening was reduced with increasing chitosan molecular weight. Fruit softening is due to deterioration in the cell structure, the cell wall composition and the intracellular materials (Seymour et al., 1993). The maintenance of firmness in the tomatoes treated with chitosan coatings could be due to their higher anti-fungal activity, and covering of the cuticle and lenticels, thereby reducing infection, respiration and other ripening processes during storage, according to previous reports in papaya and sweet cherry coated with chitosan and aloe vera gel (Ali et al., 2005; Martínez et al., 2006). Reduction of respiration and decrease in water loss may result in retention of firmness during storage. Using of appropriate coating could contribute to this (Tasdelen and Bayindirli, 1998).

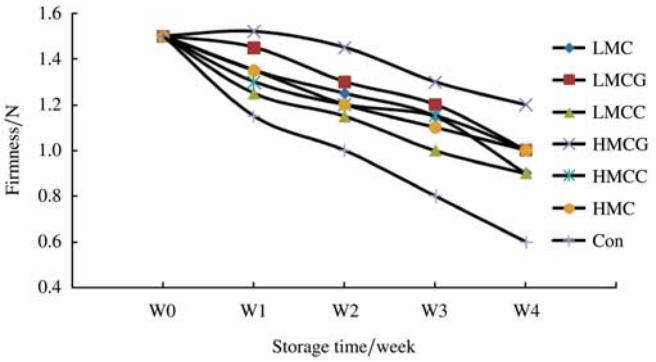

Figure 1 Effect of chitosan coating on firmness of tomatoes fruits during storage

3.2 Weight loss

Application of chitosan coating retarded the weight loss of tomato fruit during storage compared with control. There was an added benefit to control weight loss by increasing concentrations of chitosan. For example, the lowest weight loss was found in high molecular weight chitosan-glucose (H.M.C.G) chitosan treatment followed by the fruits coated with high molecular weight chitosan and then uncoated tomato fruits (Figure 2). Loss of weight in fresh fruit and vegetable is mainly due to the loss of water caused by transpiration and respiration processes (Zhuetal., 2008). Chitosan coating forms a layer of semi-transparent to smooth the pericarp surface (Dong et al., 2004) and can be used as a protective barrier to reduce respiration and transpiration rates through fruit surfaces (Kester and Fennema, 1986). Coating the tomato fruit with chitosan was clearly effective in conferring a physical barrier to moisture loss; therefore, a decreased weight loss in the chitosan-coated fruit was

observed during evaluation in our study. Our results are supported by Ali et al.(2011), where water loss of papaya fruit can be reduced by coating with chitosan. Apart from tomato fruit, chitosan coatings have been effective at controlling weight loss from other commodities, including cucumber and pepper (El Ghaouth et al., 1991), longan fruit (Jiang and Li, 2001), strawberry fruit (Hernándezetal., 2008) and mushroom (Jiang et al., 2012).

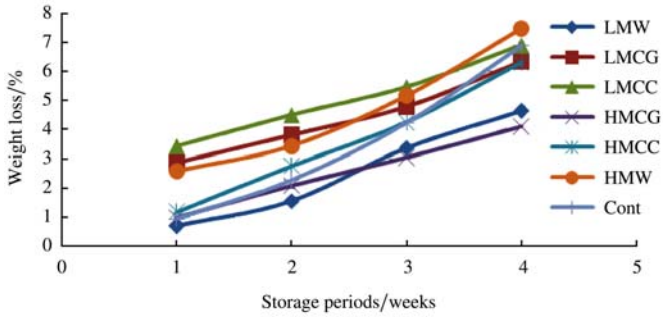

Figure 2 Effect of chitosan coating on weight losses of tomato during storage

3.3 Titratable acidity (TA)

Acidity loss has been associated with quality loss during tomato postharvest storage (Zapata et al., 2008). Changes in titratable acidity of tomatoes coated with high and low molecular weight chitosan-citric and chitosan glucose mixtures and stored at 7±2°C for 28 days are represented in Table 1. In most treatment the coating brought a decrease in titratable acidity (TA). Titratable acidity in all samples reduced over time and was affected by chitosan coating and chitosan molecular weight. Chitosan coated tomatoes stored for four weeks had significantly (p≤0.05) higher acidity compared with the uncoated tomatoes. This may be maintaining the coating with 1% chitosan mixed with citric or glucose did not completely inhibit the metabolic changes in the fruits. Han et al. (2004) reported that the chitosan coating slowed down the changes in TA of strawberry and raspberry, effectively delaying fruit ripening. Han et al. (2004) also observed lower acidity loss during storage in strawberry, peach, tomato and litchi coated with chitosan. With respect to total acidity, the effect of both molecular weights was clear on retarding the total acidity loss especially for stored tomato fruit coated with low molecular weight chitosan, while control tomatoes exhibited a larger reduction (p≤0.05) in total acidity over storage.

Table 1 Effect of coating with shrimp chitosan on the Titratable Acidity(%) of the stored tomatoes

Storage periods weeks	Control	High molecular weight shrimp chitosan			Low molecular weight shrimp chitosan		
	Uncoated	High M.w. chitosan (H.M.C)	High M.w. chitosan-citric (H.M.C.C)	High M.w. chitosan-glucose (H.M.C.G)	Low M.w. chitosan (L.M.C)	Low M.w. chitosan-citric (L.M.C.C)	Low M.w. chitosan-glucose (L.M.C.G)
0	0.78^{aA}	0.78^{aA}	0.79^{aA}	0.78^{aA}	0.78^{aA}	0.78^{aA}	0.78^{aA}
1	$0.72^{ab\ A}$	0.75^{aA}	$0.77^{\ aA}$	0.76^{aA}	0.75^{aA}	$0.65^{\ b\ B}$	$0.67^{\ b\ BC}$
2	0.65^{bB}	$0.69^{ab\ B}$	$0.71^{\ a\ B}$	$0.70^{ab\ B}$	0.68^{abB}	0.75^{aA}	$0.65^{\ b\ C}$
3	$0.62^{b\ B}$	$0.65^{b\ B}$	$0.65^{\ b\ C}$	$0.66^{\ a\ C}$	0.67^{bB}	0.74^{aA}	$0.72^{\ a\ AB}$
4	$0.61^{c\ B}$	$0.72^{ab\ AB}$	$0.67^{\ b\ B}$	$0.70^{ab\ B}$	0.71^{aAB}	0.75^{aA}	$0.73^{\ a\ AB}$

Note: * Means in the same column with different capital letters are significantly different at p≤0.05.

* Means in the same row with different small letters are significantly different at p≤0.05.

3.4 Total soluble solids (TSS)

Table 2 represents the changes in TSS of stored tomatoes coated with different chitosan edible coating. Generally all coated and un-coated tomatoes had T.S.S content within the range of 8.5 to 9.25. Significant (p≤0.05) increase was observed in the tomatoes coated with LMCG compared with other coated and uncoated tomatoes especially during the first three weeks of storage. Generally, the fruits coated with low molecular weight chitosan had a higher ($p \geq 0.05$) T.S.S. compared with that coated by the high molecular weight chitosan. The respiration and O_2 consumption of coated tomatoes were lower than those of uncoated tomatoes (Park et al., 1992). The uncoated tomatoes stored for three and four weeks had significantly (P≤0.05) lower T.S.S. compared with the first two weeks of storage this may be due to the increase of water evaporation with exceeding the storage time. On the other side, coating with both chitosans

molecular weight increased ($P \leq 0.05$) the T.S.S. of the stored tomato fruits. The highest ($P \leq 0.05$) T.S.S. was observed in the tomato fruits coated with L.M.C.C and L.M.C.G and stored for four weeks (11%).

Table 2 Effect of coating with shrimp chitosan on the T.S.S of the stored tomatoes

Storage periods/ weeks	Control	High molecular weight shrimp chitosan			Low molecular weight shrimp chitosan		
	Uncoated	High M.w. chitosan (H.M.C)	High M.w. chitosan-citric (H.M.C.C)	High M.w. chitosan-glucose (H.M.C.G)	Low M.w. chitosan (L.M.C)	Low M.w. chitosan-citric (L.M.C.C)	Low M.w. chitosan-glucose (L.M.C.G)
0	$9.1^{a B}$	$8.7^{a C}$	$9.0^{a D}$	$9.20^{a C}$	$9.0^{a C}$	9.0^{aD}	$9.10^{a C}$
1	$9.0^{d B}$	$10.0^{b B}$	$9.5^{c C}$	$10.0^{b B}$	$9.0^{d C}$	$9.5^{c C}$	10.5^{aA}
2	$9.0^{d B}$	$9.8^{bc B}$	$9.5^{c C}$	$10.0^{b B}$	$10.0^{b B}$	$10.5^{a B}$	10.5^{aA}
3	$9.6^{c A}$	10.5^{aA}	10.5^{aA}	$10.0^{b B}$	10.5^{aA}	$10.5^{a B}$	10.5^{aA}
4	$9.5^{d A}$	$10.5^{b A}$	$10.0^{c B}$	$10.5^{b A}$	$10.5^{b A}$	11.0^{aA}	$11.0^{a B}$

Note: * Means in the same column with different capital letters are significantly different at ($p \leq 0.05$).

* Means in the same row with different small letters are significantly different at ($p \leq 0.05$)

3.5 pH

No significant differences ($P > 0.05$) in pH were observed among the uncoated tomatoes and that coated with different coating mixture before storing (Table 3). The same trend was noticed after one and four weeks of cold storage (except tomatoes coated with L.M.C and L.M.C.G). Meanwhile, the increasing of cold storage time significantly ($p \geq 0.05$) increased the pH in all uncoated and coated tomatoes. The pH reached to the highest values after three weeks of coated cold stored tomatoes.

During ripening there is degradation of pectin that changes the diffusivities of gases through the skin of the tomato. The chitosan molecular weight is one of the factors determining film thickness which in turn affect its moisture and gas permeability. Generally, no significant ($P > 0.05$) difference was observed in pH, titratable acidity and T.S.S. among the tomato fruits coated with chitosan, chitosan citric and chitosan glucose (Table 4). Meanwhile coating with chitosan- glucose complex improved ($p \geq 0.05$) the weight loss of the stored tomatoes compared with that coated with chitosan alone and that coated with chitosan citric. On the other side, coating with low molecular weight chitosan reduced the weight lose by 16.48% compared with that coated with high molecular weight chitosan.

On the other side, the T.S.S. of the stored chitosan coated tomatoes increased ($p \geq 0.05$) with increasing the storage period while, no significant ($P > 0.05$) difference was noticed in firmness with increasing the storage period (Table 5). Generally, all the stored tomatoes had significantly ($p \geq 0.05$) higher pH and titratable acidity compared with the unstored fruits, while both of them did not affect significantly ($P > 0.05$) with increasing the storage time more than seven days. On the other hand, no significant ($P > 0.05$) change was detected in sensory attributes (colour, texture, taste, flavor and overall acceptability) of the tomatoes fruits coated with different coat complexes (Table 6).

Table 3 Effect of coating with shrimp chitosan on the pH of the stored tomatoes

Storage periods/ weeks	Uncoated	High Molecular Weight shrimp chitosan			Low Molecular Weight shrimp chitosan		
		High M.w. chitosan (H.M.C)	High M.w. chitosan-citric (H.M.C.C)	High M.w. chitosan-glucose (H.M.C.G)	Low M.w. chitosan (L.M.C)	Low M.w. chitosan-citric (L.M.C.C)	Low M.w. chitosan-glucose (L.M.C.G)
0	4.02^{aC}	4.02^{aD}	4.06^{aB}	$4.05^{a B}$	4.04^{aC}	$4.05^{a C}$	4.02^{aC}
1	4.10^{bC}	4.21^{aB}	4.23^{aA}	4.25^{aA}	4.10^{bB}	4.25^{aA}	4.13^{bB}
2	4.22^{aB}	4.22^{aB}	$4.23^{a A}$	4.26^{aA}	4.23^{aA}	4.23^{aA}	4.12^{bB}
3	4.28^{aA}	4.31^{aA}	4.25^{abA}	4.28^{aA}	$4.25^{a b A}$	4.30^{aA}	4.20^{bA}
4	4.25^{aAB}	$4.16^{b BC}$	4.25^{aA}	4.23^{aA}	$4.16^{b AB}$	4.25^{aA}	4.25^{aA}

Note: * Means in the same column with different capital letters are significantly different at ($p \leq 0.05$).

* Means in the same row with different small letters are significantly different at ($p \leq 0.05$)

Table 4 Effect of coating with different chitosan complexes on titratable Acidity (%), PH, T.S.S, Firmness and Wight loose of tomatoes

Physico-chemical properties	Chitosan Type			L.S.D	Chitosan Type		
	Chitosan	Chitosan Citric	Chitosan Glucose		low M.W Chitosan	High M.W Chitosan	L.S.D
PH	4.17 [a]	4.21 [a]	4.17 [a]	0.08	4.17 [a]	4.20 [a]	0.06
Acidity (%)	0.71 [a]	0.72 [a]	0.71 [a]	0.04	0.72 [a]	0.71 [a]	0.03
T.S.S	9.85 [a]	9.9 [a]	10.13 [a]	0.61	10.07 [a]	9.84 [a]	0.49
Firmness	1.24 [b]	1.18 [b]	1.35 [a]	0.1	1.21 [b]	1.32 [a]	0.1
Wight loss (%)	3.62[b]	4.35 [a]	3.34[c]	0.25	3.04[b]	3.64 [a]	0.58

Note: Means in the same row with different small letters are significantly different at ($p \leq 0.05$).

Table 5 Effect of coating with different chitosan complexes on the titratable Acidity (%), PH, T.S.S, firmness and weight loose of stored tomatoes

Physico-chemical properties	Storage period (week)					L.S.D
	0	1	2	3	4	
pH	4.04 [b]	4.19 [a]	4.21 [a]	4.26 [a]	4.21 [a]	0.05
Acidity (%)	0.78 [a]	0.72 [b]	0.69 [b]	0.68 [b]	0.71 [b]	0.04
T.S.S	9.00 [d]	9.75 [c]	10.05 [bc]	10.41 [ab]	10.58 [a]	0.42
Firmness	1.50 [a]	1.36 [b]	1.22 [c]	1.09 [d]	0.95 [e]	0.12
Wight loose	-	1.80 [d]	2.94 [c]	3.90 [b]	6.10 [a]	1.10

Note: Means in the same row with different small letters are significantly different at ($p \leq 0.05$).

Table 6 Effect of coating with shrimp chitosancomplexes on the sensory attributes of coated tomatoes

Sensory attributes	Uncoated	High Molecular Weight shrimp chitosan			Low Molecular Weight shrimp chitosan		
		High M.w. chitosan (H.M.C)	High M.w. chitosan-citric (H.M.C.C)	High M.w. chitosan-glucose (H.M.C.G)	Low M.w. chitosan (L.M.C)	Low M.w. chitosan-citric (L.M.C.C)	Low M.w. chitosan-glucose (L.M.C.G)
Colour	9.22[a]	9.12 [a]	9.06 [a]	9.17 [a]	9.16 [a]	8.95 [a]	9.17 [a]
Texture	8.31 [a]	8.21 [a]	8.23 [a]	8.35 [a]	8.18 [a]	8.25 [a]	8.13 [a]
Taste	9.32 [a]	9.18 [a]	9.23[a]	9.46 [a]	9.09 [a]	9.23 [a]	9.12 [a]
Flavor	8.28 [a]	8.31 [a]	8.25 [a]	8.28 [a]	8.25 [a]	8.30 [a]	8.20 [a]
Over all accepality	8.78 [a]	8.70 [a]	8.69 [a]	8.81 [a]	8.67 [a]	8.68 [a]	8.65 [a]

Note: Means in the same row with different small letters are significantly different at ($p \leq 0.05$).

4 Conclusion

Coating tomatoes fruits by different shrimp chitosan complexes enhanced the quality of tomatoes fruits stored at 7±2°C temperature by keeping the firmness and decreasing the weightloss. The high molecular weight chitosan showed more efficiency as an edible coat comparedwith the low molecular weight. The high molecular weight chitosan-glucose complex had thehighest efficiency to keep duration of tomato fruits rather than the other complexes. Thus chitosan glucose complex seems to be a novel natural preservative and it may have promising applications in the food industry.

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