EFFECTS OF CHITOSAN ON QUALITY PARAMETERS DURING THE STORAGE OF TOMATOES (*Lycopersicones culentum Mill)* AT ROOM CONDITION (~30^{O}C)

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Abstract
Tomato (Lycopersicones culentum Mill) was planted and eaten around the world, especially in Europe and North America. Tomato is used in diverse ways and it is a food with high nutrition value, especially lycopen (one of the most powerful natural antioxidants) but tomato is easy damage during storage. Therefore, they use chitosan to preserve tomatoes and it can extend the shelf life of fruits. The goal of this research determines the influence of chitosan on the quality parameters during the storage of tomatoes in Vietnam. The tomato samples were coated by chitosan film (chitosan dissolved in HCl 1%) at concentrations of 0, 0.5, 1, 1.5, 2 and 2.5% at a temperature of 31±2^{o}C, relative humidity at 72±10% (the normal conditions). We evaluated about the ripening rate, loss of weight, chemical composition of fruits such as soluble solids content (^{o}Bx), reducing sugars (glucose), total acid concentration and the change of color. The results showed that concentration of chitosan 2% has the best preservation. Tomatoes after chitosan treatment were preserved during 28 days, ripe fruits obtained nearly 30% at 28th day. The coated chitosan samples have the normal color and brighter than the uncoated samples. The consumers can not recognize the difference between the coated and uncoated chitosan samples by the sensory evaluation.

Keywords: Chitosan, edible film, preservation, tomato, reducing sugar.

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1.INTRODUCTION

Tomato (*Lycopersicon esculentum Mill*) is an herbaceous, with full body, multiple branch distribution, from 0.6 to 1.0 meter height. The fruits are egg-shaped, pear-shaped, etc. (Hoang, 2005). Depending on the characteristics of cultivar, when the fruits became ripe that have different colors like red, yellow, pink, etc (Le, 1997). Pigment of tomatoes is mainly carotenoids, chlorophyll. Chlorophyll decreases, but carotenoid increases following the ripeness level. The fruits are higher quality more than others which have thicker pericarp tissue and smaller locular cavities. At full-ripeness, the highest rate of vitamin C and carotenoids, reducing acids concentration, sugars level rising. In Vietnam, tomato was cultivated in the few cool area and was sold at a lot of local market. Climate in Vietnam is hot, average temperature at approximate 30^{o}C, it's very difficult to preserve the tomato. The store in local market can not afford to preserve fruits in cold condition. There are some methods to improve the fruit life by edible film as chitosan treatment. Chitosan is a natural polysaccharide derived from chitin, which is found in the shells of crustaceans, insects, and cuticle cells of mushrooms. Chitosan membranes have been explored successfully in testing on foods such as eggs, fruits, vegetables, dairy products and meat (Bhale et al, 2003, Chien et al, 2007, El Ghaouth et al, 1992) in which it has been observed that the use of chitosan protects against contamination and damage of bacteria, improve quality fruit, decrease the respiratory rate of food and also inhibit the microbial growth (Agulló et al, 2003). Alternatively, chitosan is cheap, non-toxic, very easy to use and buy. It maybe applies widely for post harvest technology in developing country, especially Vietnam.

The aim of this research was to study about effecting chitosan on maturing of tomato at a high temperature (~30^{o}C).

2. MATERIALS AND METHODS

Materials and treatments

Tomatoes were harvested from Lam Dong province, Vietnam.

Table 1. The ripeness stage of tomatoes

Ripeness Stage[1]	External Color
(1) Green	Fruit surface is completelygreen; the shade of green mayvaryfromlight to dark.
(2) Breaker	there is a definite break in color fromgreen to tannish-yellow, pink or red on not more than 10% of the surface.
(3) Turning	10% to 30% of the surface is not green; in the aggregate, shows a definite change fromgreen to tannish-yellow, pink, red, or a combination thereof.
(4) Pink	30% to 60% of the surface is not green; in the aggregate, shows pink or red color.
(5) Light red	60% to 90% of the surface is not green; in the aggregate, shows pinkish-red or red.
(6) Red	More than 90% of the surface is not green; in the aggregate, shows red color

Tomatoes ripen when it achieved the ripeness stage at level 5 (Light red) and level 6 (Red)

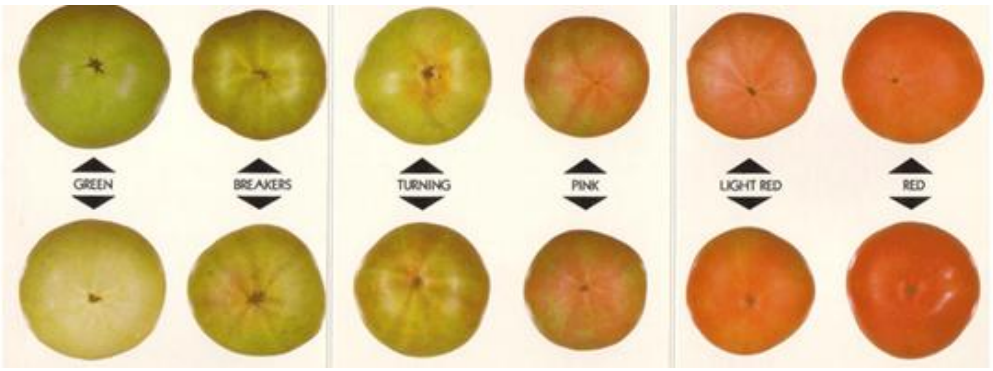

Figure 1. USDA's Tomato Color Chart

Fruits were uniformed in terms of shape, size, and color. The size of a tomato is determined by either its diameter or weight. Fruits must be intact, bright, clean, no handicap and pest. Fruit was chosen at ripeness stage level 2 (Table 1). The fruits diameter is 5.25±0.4 cm and weight is 90±7.07g.

Chitosan (degrees of deacetylation of 82%, China) solution was prepared by dissolving chitosan in 1% hydrochloric acid under continuous stirring. Tomatoes were dipped in solutions for 1 min and then left for 1 hour at room temperature. Samples of the control were not dipped in chitosan solution. All samples were kept in plastic baskets covered with canvas at storage temperature of 31±2^{o}C, humidity 72±10%.

Methods

Ripeness stages are defined according USDA (1991).

Determination of weight loss was the 4th, 8th, 12th, 16th, 20th, 24th and 28th day after treating by chitosan. Weight loss was expressed as percentage of initial weight:

$$m\ (\%) = \frac{m_t - m_s}{m_t} \times 100$$

m: Percentage of weight loss (%)

m_t : Weight of fruit at the day before (g),

m_s : Weight of fruit at the day after (g).

Determination of titratable acidity was following by (AOAC 942.15, 2000). Titration acidity was performed by NaOH 0.1N with

phenolphthalein 0.1% as an indicator. Total acidity was converted by malic acid.

Reducing sugar (RS) was determined with a glucometers and was calculated by using the following formula (Quoc et al, 2013)

$$RS(\%) = X \times 10^{-3} \times 180 \times \frac{V}{1000 \times m} \times 100$$

X: The number displayed on the screen of the glucometers (mmol/L),
180 is the unit of glucose molecules,
V: The dilution of solution (ml)
m: The weight of sample (g).

The peel color change is determined based on CIELAB color measurement system. The color parameters were measured by Minota CR-410 (Japan) such as "L*" is the ratio of lightness and darkness (0 = Black, 100 = White), "C*" specifies chroma and "h" denotes hue angle (Schanda, 2007).

The sensory evaluation test method was the simple difference test (or the same/different test) (Lawless et al., 2010) with 24 participants.

Data analysis uses Statgraphics Centurion XV with confidence interval 5%. Each samples has weight of 900±8g, corresponding to 10 units and repeated three time.

3. RESULTS AND DISCUSSIONS

3.1. Effect of chitosan on tomato maturity and weight loss during preservation time

Figure 2 shows the rate of ripe tomatoes in different chitosan concentrations was increased over storage time. In particular, transition time from breakers to full-ripeness of the coated chitosan samples longer than non-embedded chitosan samples. Speed of ripening process of uncoated chitosan samples increased rapidly, at 12th day with ripe rate is 73.33%. Besides, coated chitosan samples were slowest with high chitosan concentration as 1.5 %, 2% and 2.5%. Ripe rate of these samples are highest at 20th day. At 28th day, almost of samples were damaged, only samples with chitosan 1.5% and 2% were still ripe fruits, ripe rate of samples with chitosan 2% still be high (30%). In addition, damaged fruit appeared from the 4th day. At 28th day all samples were damaged. During storage time, the fruit ripen quickly because of ethylene and aerobic respiration (Ton et al., 2008). However, chitosan covered all surface of fruit which can not contact with outside environment, especially oxygen, storage time of fruit was better (Le et al., 2008).

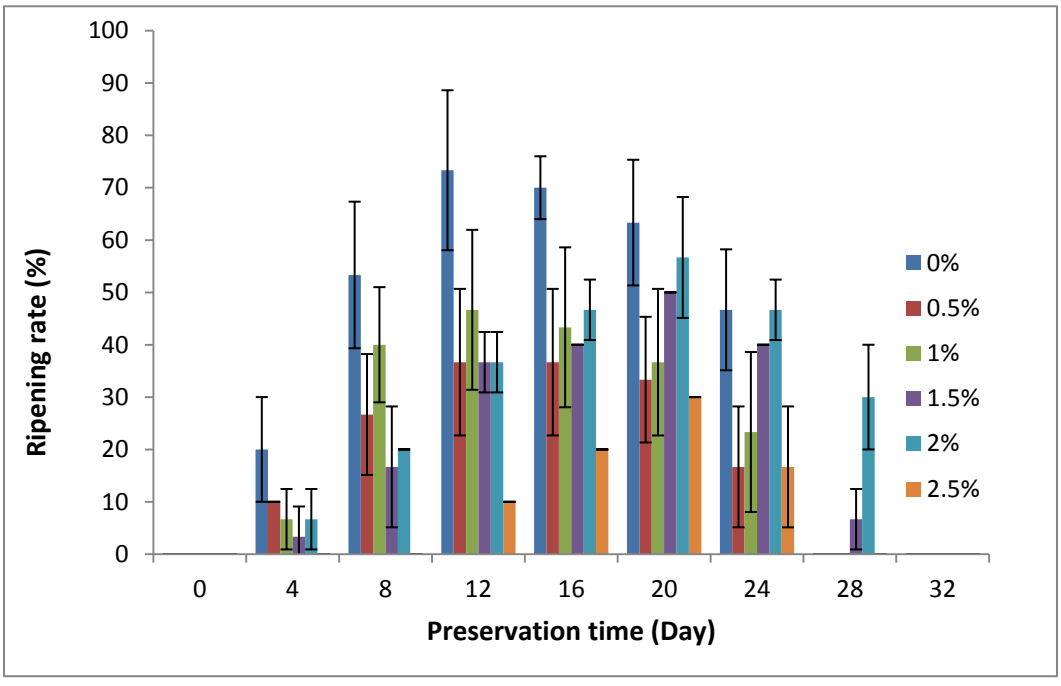

Figure 2. Changes in ripping stage of tomatoes with concentration of chitosan

Fruit decreased the weight in storage time because the respiration and the process of evaporation but the process of evaporation was the main reason (Ton et al., 1999). Figure 3 showed that sample with 2% and 2.5% chitosan were not a statistically significant at the 95% confidence level at 24th day, sample 2% chitosan has the weight loss (14.3%). This result is higher the study of Thumula (2006) in the preservation of tomato by chitosan and lysozyme film at 22^{o}C (approximate 10.5% after 21th day). Fruits coatings with chitosan at concentration of 1.5 and 2% better in limiting transpiration and respiration of the fruit.

3.2. Effect of chitosan on glucose and total acid content

During storage time, content of starch decreased due to the saccharification process by the effect of some special enzymes. Total sugar reaches to maximum value then decreasing, hemicellulose becomes pentose (xilose, mannose, galactose, arabinose) and reducing sugar, cells structure was destroyed. Then dry soluble matter content increases, but the amount of sugar decreases because of glucose metabolism into energy to maintain respiratory activity of the fruit (Le et al., 2008). Figure 4 showed that reducing sugar in all samples increased. It is due to reduced starch content by the saccharification process (Ton et al, 2008). Samples were dipped in chitosan solution with high concentrations of 2% and 2.5% which have been shown to slow down the sugar content. Thus, high concentrations of chitosan coating have contributed to limiting the respiratory process and glucose which was the main material for the respiration, that reason why reducing sugar decreased slowly. Tomatoes in the full-ripeness stage at 16th and 20th day that have the maximum glucose content range 1.6% to 2%.

The total acid content of fruit decreased during the storage time (Nguyen et al, 1999). The figure 5 shows the acid total of tomatoes also decreased slowly from first day to 28th day. However, there are not major differences between the samples. In the full-ripeness stage, total acid content maintained from 10.24-13.5 g/l, all samples were not a statistically significant at the 95% confidence level in this stage. Tomatoes with chitosan 2%, the total acid content maintained steady in all samples during full-ripeness stage. Chitosan-coated tomatoes were higher in titratable acidity than the control fruit at the end of storage; it was absolutely suitable with the study of El Ghaouth et al (1992). The samples 2% chitosan was the best of all samples.

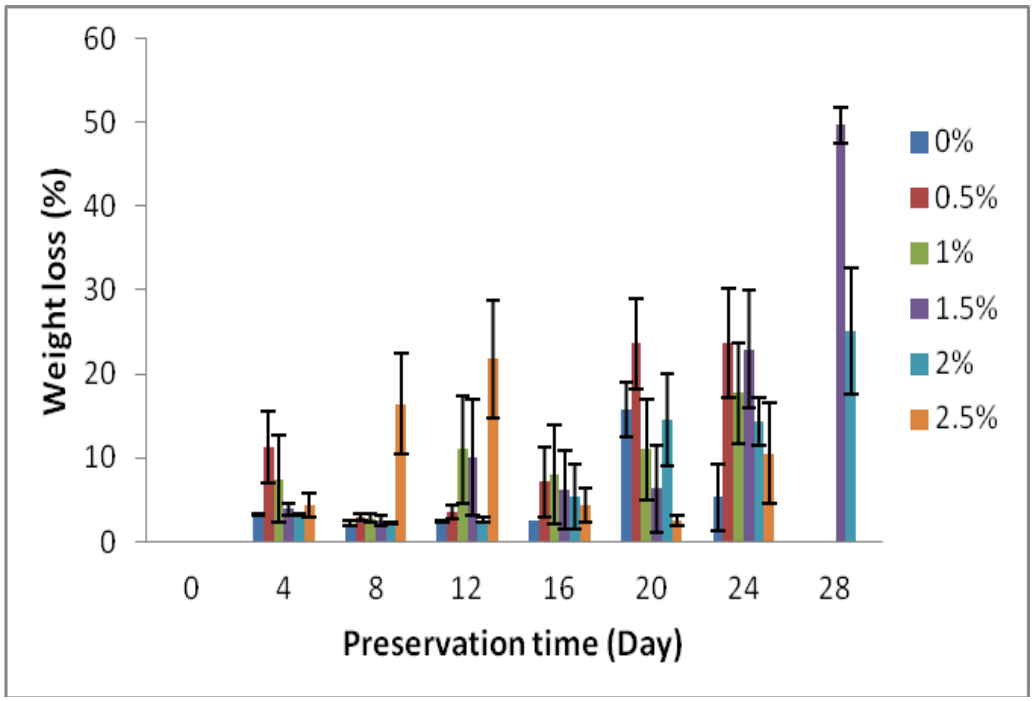

Figure 3. Changes in the weight loss of tomatoes with concentration of chitosan

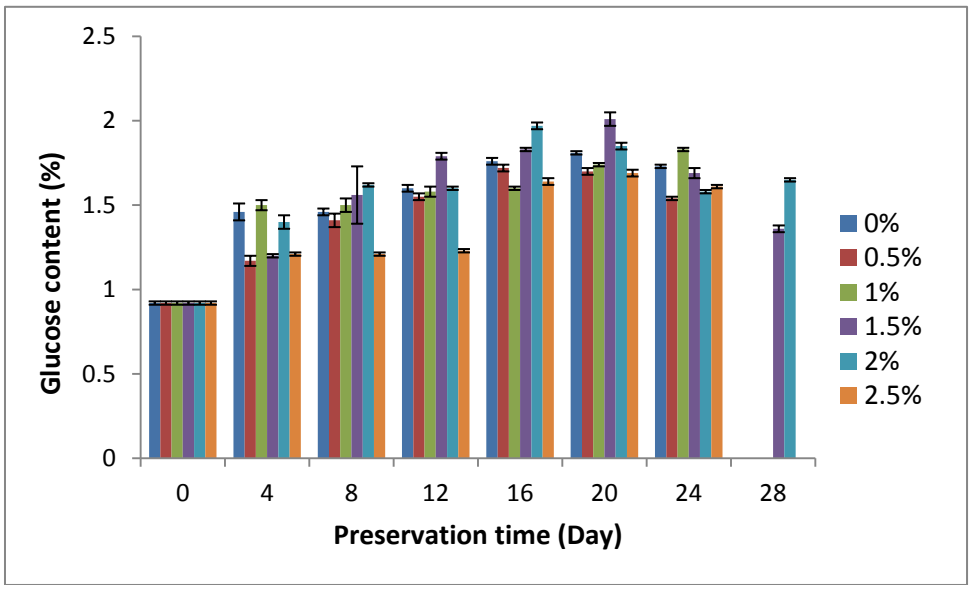

Figure 4. Changes in the glucose content with concentration of chitosan

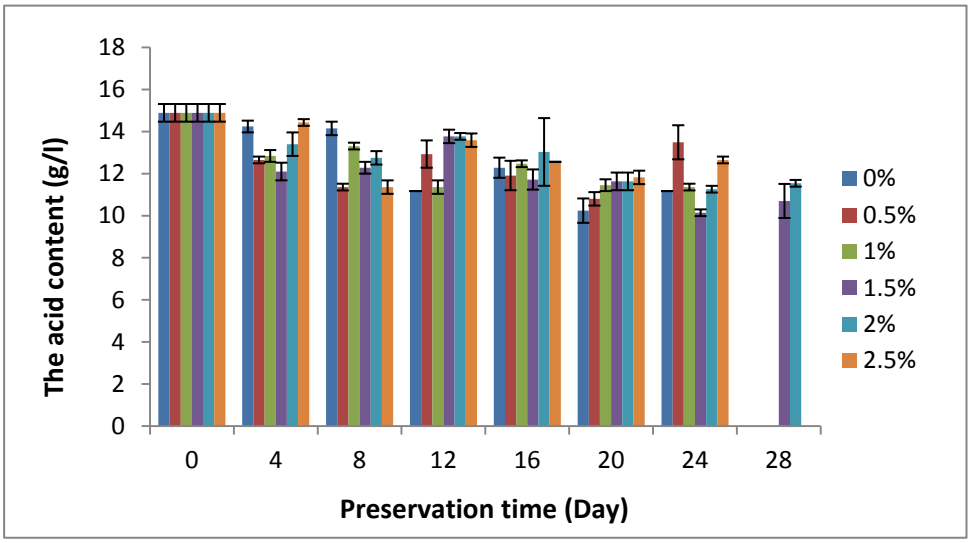

Figure 5. Changes in the acid content with concentration of chitosan

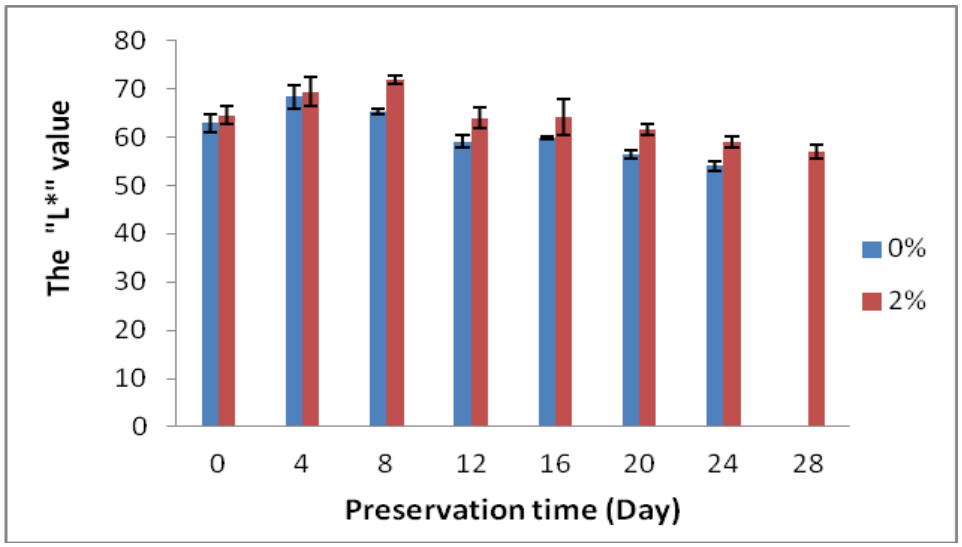

Figure 6. Changes in the L* value during preservation time

3.3. Effect of chitosan to the color of tomatoes

During ripening the green chlorophyll pigment is degraded and there is accumulation of carotenoids giving the red color to the ripe fruit (Nguyen, 1999), especially tomato. The L* value increased during the first 8 days and less change was seen thereafter. From 8th to 28th day, chitosan coating samples was significantly different ($p<0.05$) from the uncoated tomatoes. The L* value for 2% chitosan treatments showed slightly higher values than uncoated chitosan treatments.

Figure 7 shows the changes in hue values that the color changes from green-yellow to red and this values decrease during preservation time. The hue value drops dramatically after 4 days storage (from 115^{o} to 70^{o}) and the hue value of the uncoated samples was significantly different from the coated ones throughout the preservation time (from 4th to 28th day). Film coating of tomatoes can extend the process of ripening and has the higher hue value than uncoated samples (Thumula, 2006).

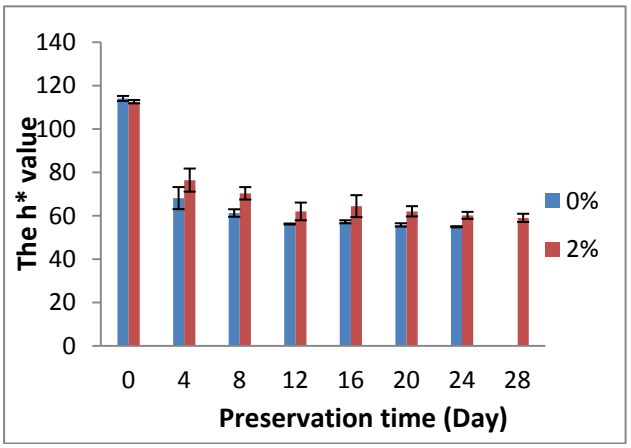

Figure 7. Change in the h* value during storage time

3.4. The sensory evaluation for tomato

Using paired comparison tests with a number of 24 pariticipants who evaluated the similarity or difference between samples with 2% chitosan solutions for 20th days and tomatoes were bought from the local market with same ripeness stage and similar color.

Table 2. Results after conducting sensory evaluation

Sample	Amount	Results	
		Same	Different
AA	6	4	2
AB	6	4	2
BA	6	4	2
BB	6	3	3

A: Samples dipped in chitosan 2%
B: Samples without chitosan.
$\chi^2 = 0.178$, $\chi^2_{cri} = 3.84$. $\chi^2 < \chi^2_{cri}$.

Thus, difference between the two samples was not considered at 5% significance level (P=0.05). In other words, consumers can not recognize the coated chitosan samples and uncoated chitosan samples.

3. CONCLUSIONS

The results points out that chitosan make to increase the shelf life of tomatoes. Chitosan with high concentrations from 1.5% to 2% preserve tomatoes better than the uncoated chitosan samples or lower content of chitosan at 1%. In this study, 2% chitosan in 1% hydrochloric acid solution is sufficient for storage of tomatoes at room condition (30^{o}C, relative humidity 72%) during 28 days, the uncoated chitosan samples have the shelf life in 24 days, almost of them was damage at the 28th day.

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