https://doi.org/10.47253/jtrss.v10i2.990

Journal of Tropical Resources and Sustainable Science

journal homepage: jtrss.org

The effects of edible chitosan coating on prolonging the shelf life of green chilies (*Capsicum annuum L.*)

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Received 29 October 2021
Accepted 18 August 2022
Online 30 December 2022

Keywords:
Concentrations, efficiency, significance change, preserve longer

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Abstract

Green chillies (*Capsicum annuum* L.) are susceptible to pest attack, experiences water loss rapidly in a short time and also experiences chilling injury when stored at a cool temperature that leads to shorter shelf life. Therefore, this study was conducted to examine the effects of chitosan at different concentrations (0.5%, 1.0% and 2.0%) on the shelf life of green chilies stored at ambient temperature (27°C) for 21 days. The effectiveness of the chitosan treatments in extending green chilies′ shelf-life was evaluated by determining their physical and chemical qualities. Coated green chilies are able to preserve for a longer period of time compared to uncoated green chilies. Regardless of any chitosan concentration, the total soluble solid content (TSS) of coated green chilies had increased starting from day 3 to day 21 day as compared to the control. At the highest concentration of 2.0%, chitosan treatment was able to reduce the pH by 28% on day 6 of the storage period, meanwhile, the pH was maintained across the concentration at the end of the storage period (day 21). It was found that the green chilies faced 10 to 22% weight loss across the concentration as compared to the control at the end of the storage period, where the highest weight loss was prominent at 2.0% chitosan. However, in terms of firmness, the chitosan treatments do not give any significant effect on all the treated green chilies. These results suggest that the application of edible chitosan coating contributes to lower pH and weight loss which is responsible for the longer shelf life of the green chilies.

1. INTRODUCTION

Edible coating refers to a method where multiple compounds are combined together to obtain benefits. The edible coating is the consumable coating that creates semipermeable blockage against carbon dioxide, oxygen and moisture by generating a modified atmosphere condition in order to prevent the earlier deterioration of the product (Ali *et al*., 2010). The application of the edible coating in food production can preserve food quality while improving its marketability and appearance (Cerqueira *et al*., 2011).

One of the most popular edible coatings, chitosan (poly- β- (1→4) N-acetyl-d-glucosamine) which is derived from chitin (outer shell) of crustaceans as crabs, shrimps as well as lobster (Islam *et a*l., 2011) contain antifungal properties and elicitation of defence responses in plant tissue (Terry and Joyce, 2004). In addition, considering its superior properties, chitosan has been used in many postharvest fruits and vegetables (Jianglian and Shaoying, 2013) such as grape (Dos Santos *et al*., 2012), mango (Khaliq *et al*., 2017), strawberry (Hernandez-Munoz et al., 2008), longan (Lin *et al*., 2018) and chilies (Muthmainnah *et al*., 2019, Lacap and Photochanachai, 2018).

Chilli is a very popular fruit vegetable among Malaysians and scientifically named Capsicum spp. and botanically known as *Capsicum annuum* L. Study showed that green chilies are prone to loss of water, sunscald and heat damage where the water losses very fast after harvest and causes green chilies to be wrinkle as well as the colour changes in few days' times when green chilies are not kept in cool storage. Green chilies are severely affected by chilling injury when the fruits were stored at or below 7°C, where the green chilies are very sensitive to cold storage.

According to Than *et al*. (2008), chilli cultivation is largely affected by anthracnose disease that origin from *Colletotrichum* species which is known as bacterial wilt caused by *Pseudomonas solanacearum*. Besides that, chilli veinal mottle virus (CVMV) and cucumber mosaic virus (CMV) are among viral diseases that can cause a decrease in chili production. It is reported that anthracnose disease is a big problem leads that to losses in chilli production in

eISSN Number: 2462-2389

tropical and subtropical countries. Green chilies are susceptible to pest and pathogen attacks during pre-harvest or after harvest, which will affect the nutrient content that affects the external appearance of green chilies and the reduction of vitamin C during the storage period.

Therefore, the aim of this study was to determine the efficiency of different chitosan coating concentrations on the physical and chemical qualities of green chilies (*Capsicum annuum* L.)

2. MATERIALS AND METHODS

2.1. Sample preparation

Green chilies (*Capsicum annuum* L.) were purchased from Ariffin Ibrahim Farm, Jeli. Kelantan. Fruits were grouped based on uniformity of size, absence of physical damage and fungal infection.

2.2. Preparation of chitosan coating

Chitosan coating was prepared by dissolving 0.5 g, 1.0 g and 2.0 g of chitosan powder in 100 ml of 1.0% (v/v) acetic acid to prepare three different concentrations of chitosan namely 0.5%, 1.0% and 2.0%. The purpose of dissolving chitosan powder in acetic acid was to allow the chitosan to dissolve completely in the acidic compound and the acetic acid did not affect the coating. The solutions were stirred and left for one hour for the compounds to completely dissolve. These coating formulations resulted in a set of treatments; T0: Control (uncoated chillies), T1: 0.5% chitosan, T2: 1.0% chitosan, and T3: 2.0% chitosan

2.3. Chitosan coating application

Before treatments, chili fruits of uniform size, colour, free from damage, and fungal infection were rinsed with tap water and air-dried. After that, the fruits were dipped individually for 30 seconds in chitosan solutions. The samples were allowed to dry for two hours at ambient temperature on a piece of absorbent paper to remove excess surface liquid. After coating and removal of excess liquid, the samples were placed on the polystyrene plates at an ambient temperature of 27^0C. The green chilies were observed through analysis carried out during three-day intervals for a total of twenty-one days.

2.4. Quality Assessment

2.4.1. Total Soluble Solid and pH

The chilies were cut and crushed in pastel and mortar to obtain juice to measure the total suspended solids (TSS) (Brix, %) according to the method of Chaple *et al.* (2016). The measurement of TSS is to evaluate the change in sugar content by using a handheld refractometer (Hand Refractometer Model 103, 0-32% Brix) and was expressed as a percentage (Valiathan and Athmaselvi, 2018). Meanwhile, for the pH, the solute obtain was added into 10 ml of distilled water (Hernandez-Munoz *et al*., 2008). The pH of the samples was measured by using a pH meter (Antoniali *et al*., 2007). The data on TSS and pH changes within days of observation at 0, 3rd, 6th, 9th, 12th, 15th, 18th and 21st days were recorded.

2.4.2. Weight loss

Chilies were weighed at the beginning of the experiment immediately after being coated and air-dried, and thereafter at the end of the storage period. The weight of each fruit was taken by using an analytical balance. The weight loss of chilies was determined by calculating the difference between the initial weight and the final weight of the fruits based on the formula of Valiathan and Athmaselvi, (2018) as in the equation below:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{initial weight}} \times 100\ \%$$

2.4.3. Firmness

The firmness of both control and coated chilies was analyzed by using TA-MTP Plus digital texture analyzer (Chaple *et al*., 2016) and measured as the maximum penetration force (N) achieved during tissue breakage and with a needle probe TA39. The penetration force (N) required to penetrate through the skin was measured on a 5 mm diameter stainless probe at the locular space and carpel wall of the whole fruit in the equatorial region (Tadesse *et al*., 2002). Fruit firmness values were evaluated at 0, 3rd, 6th, 9th, 12th, 15th, 18th and 21st days of storage.

2.5. Statistical analysis

This experiment was arranged as a completely randomized design (CRD) with three replications. Statistical analysis of the results was performed using a one-way analysis of variance (ANOVA). Tukey HSD was used to compare means between treatments. Differences were considered significant when the p-value was less than 0.05 ($p < 0.05$).

3. RESULT AND DISCUSSION

3.1. Total Soluble Solid (TSS) and pH

There was a steady decrease throughout the storage period till day 12 of uncoated green chilies, whereas TSS slightly increased on day 15 and day 21 (Table 1). The higher TSS value on the 3rd and 21st day of 1.0% chitosan concentration compared to 0.5% chitosan also depicted a higher amount of TSS although there was a slight drop in between the storage period. Despite this, 2.0% chitosan treatment showed increment value of TSS where the increased value remained the highest in between the storage period whereas 1.0% chitosan was relatively higher (6.56% Brix) at the end of the storage period when compared to other treatments. The increased TSS values

eISSN Number: 2462-2389

indicated that the green chilies were undergoing ripening process as stated by Castro *et al*. (2008) and Ghasemnezhad *et al*. (2011). In addition, Miranda-Molina *et al*. (2019) found that other fruits of the genus Capsicum went through a ripening process by showing colour changes and a rise in TSS content.

Table 1: Average mean of Total Soluble Solids (TSS) of green chillies. Means within column with different letter(s) indicate significant difference between treatments by Tukey's HSD test at p ≤ 0.05.

	TSS Content (Brix, %)							
Days	0	3	6	9	12	15	18	21
Treatment								
T0	6.67a	5.13a	4.80a	3.38a	3.38a	3.61a	2.86a	3.91a
T1	5.80a	6.10a	5.28a	6.80a	6.07a	5.88a	6.61a	5.98a
T2	4.47ab	7.83c	5.50ab	6.25bc	5.13ab	3.69a	6.15bc	6.56bc
T3	5.96bc	7.33c	4.94bc	3.13a	3.48ab	5.38c	6.38c	6.18bc

Meanwhile, 2.0% chitosan concentration was among the highest even though there was a slight decrease on day 21 with the pH value of 3.53 (Table 2). However, 2.0% chitosan concentration results in higher pH compared to other treatments at the end of the storage period. According to Bal (2013), the rise in pH can be a factor due to a decrease in titrable acid content in fruits and while the higher levels of titratable in coated fruits resulted from a protective oxygen barrier or the lower oxygen supply to internal fruit surface stops the respiration rate. The effect of chitosan on pH values has similar results reported by Ghasemnezhad *et al.* (2010) in apricots (*Prunus armeniaca* L.) and apples (*Malus domestica* Borkh. cv. Gala) (Shao *et al*., 2012). A study conducted by Adetunji *et al*. (2014) found that the change in pH of green bell pepper (*C. annuum*) is associated with the effect of chitosan treatments on the biochemical condition of the fruit and rate of respiration with lower metabolic activity.

Table 2: Average mean of pH of green chillies. Means within column with different letter(s) indicate significant difference between treatments by Tukey's HSD test at p ≤ 0.05.

	pH							
Day	0	3	6	9	12	15	18	21
Treatment								
T0	7.17 d	6.23c d	6.10b cd	4.90ab cd	2.60a	3.93a bc	4.19abcd	3.03ab
T1	7.20 b	5.10a b	3.63a	3.40a	5.97ab	3.83a	4.32ab	3.37a
T2	5.50 ab	7.37b	3.23a	5.90ab	5.00ab	3.60a	3.77a	3.27a
T3	6.60 a	5.13a	4.40a	5.90a	4.13a	5.87a	4.80a	3.53a

3.2 Weight loss

There was a significant reduction ($p<0.05$) in weight loss between uncoated green chilies with coated green chilies of 0.5% chitosan and 2.0% chitosan as shown in Figure 1. Control treatment or uncoated green chilies showed the highest weight loss (46.90%) compared to the other treated coated green chilies during 21 days' storage whereas, the lowest percentage of weight loss is 2.0% chitosan (24.58%). This might be due to the higher concentration of chitosan preserving the green chilies well in this treatment as it is the quality of 2.0% chitosan-coated green chilies.

Miranda-Molina *et al*. (2019) demonstrated that transpiration caused the loss of mass of horticultural products by reducing the vapour pressure between the internal tissue and the environment. They also found that the Serrano chili peppers (*C. annuum*) experienced weight loss when stored at an ambient temperature of 25°C. This was due to the higher rate of transpiration explained by higher thermal conditions and lower relative humidity of the storage room. In addition, water loss caused by chilling injury is a factor that stops the shelf life of organic cherry peppers (*Capsicum annuum* L. cv. Cherry) (Avalos-Llano *et al*., 2018). This finding was in line with the current study where the deterioration of green chilies during the storage period was prominent in uncoated green chilies.

Weight loss is mainly caused by the release of moisture from the fruit to the environment and the oxidation of organic acids during respiration. Therefore, the application of 2.0% chitosan proves that green chilies can be preserved well and the quality can be maintained as the concentrated solution of chitosan component prevent water loss from 2.0% chitosan coated green chilies.

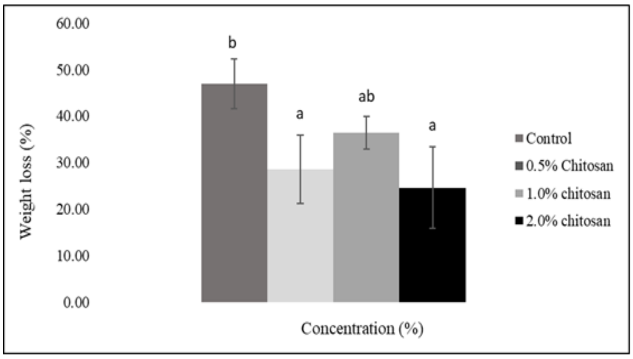

Figure 1: Effect weight loss on green chillies treated with chitosan after 21 days. Means within column with different letter(s) indicate significant difference between treatments by Tukey's HSD test at p ≤ 0.05.

3.3 Firmness

Throughout the storage period, it was found that there is no significant effect on the firmness of green chilies after being treated with chitosan (Table 3). However, the chitosan concentration at 1.0% and 2.0% showed a higher value of firmness as it increases during the storage period of 21 days even though there was a slight drop compared to control and 0.5% chitosan-coated green chillies. At the end of storage, the coated green chilies exhibited a higher increase in firmness as chitosan concentration increased. The increase was remarkable at 2.0% chitosan with a 72% (10.60 N) increase in the textural property as compared to the control (2.90 N). This finding is supported by a study conducted by Khaliq *et al*. (2017) where the mango fruit (*Mangifera indica* L.) treated with 1.0% and 1.5% chitosan maintained the firmness of fruits compared to control and fruit treated with 0.5% chitosan.

Even though no significant effect was observed among the treatments applied, chitosan coatings showed a positive effect on the green chilies' firmness throughout the storage period as 1.0% and 2.0% chitosan solution generally give higher flesh firmness values compared to 0.5% concentration solution. This result was in accordance with Nasrin *et al*. (2018) where chitosan at 1.0% and 1.5% concentration had preserved the firmness of mandarin fruit (*Citrus reticulata*) more efficiently than 0.5% chitosan.

Table 3: Average mean of firmness of green chillies. Means within columns with a different letter(s) indicate significant difference between treatments by Tukey's HSD test at $p \leq 0.05$

	Firmness (N)							
Days	0	3	6	9	12	15	18	21
Treatment								
T0	10.27a	7.95a	5.61a	4.51a	3.36a	2.79a	4.07a	2.90a
T1	9.31a	11.24a	8.61a	9.49a	9.11a	8.93a	4.74a	6.53a
T2	9.17a	10.17a	10.65a	10.44a	9.99a	10.51a	8.13a	9.34a
T3	11.95a	11.42a	12.47a	7.95a	6.53a	6.90a	10.11a	10.60a

4. CONCLUSION

Chitosan edible coating is effective in preserving the shelf life of green chillies physically and biochemically by providing a semi-permeable layer on the coated green chillies which helps to delay the deterioration. Chitosan coating at 2.0% was markedly affect the pH, weight loss and firmness of green chillies during 21 days of storage. Our results suggest that this treatment may be used to maintain the postharvest quality and prolong the shelf life of green chilies and other fresh produces.

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eISSN Number: 2462-2389

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eISSN Number: 2462-2389