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The Effect of Chitosan Coating on Post-harvest Quality of Banana in Cold Storage

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ABSTRACT

Banana (Musa acuminata) is a widely grown fruit crop in the tropical region. However, banana is climacteric and has relatively short storage life as well as being a highly perishable crop. The high respiration rate due to the rapid ripening from the production of ethylene in the fruit during storage and other post-harvest damage such as bruising, rotting, breaking, scarring and blemishes is the main factor that reduce the quality of harvested banana in the market. Due to that problem, the use of preservative and edible coating such as chitosan is important to improve the shelf -life of banana. This research is conducted to assess the effect of chitosan in maintaining the post-harvest quality of banana stored in cold room. Three different concentrations of chitosan at 0.5%, 1.5% and 2.5% are used – one an experimental and the other two treatments as control where one control is without chitosan and stored in cold room, and the other control is coated with chitosan and stored in room temeprature. The quality evaluation is determined based on percentage of weight loss, total soluble solid (TSS), total acidity (TA) and storage time. The result showed that banana coated with chitosan can prolong the shelf-life and help maintain the quality of banana. Banana coated with 1.5% of chitosan exhibit less of total soluble solid and total acidity and prolong the shelf-life. These findings suggest that chitosan can be used as a coating agent for banana in storage for extending the shelf-life.

Keywords: *Chitosan, Musa acuminata, Cold Room, Postharvest, Shelf Life*

1. INTRODUCTION

Banana (*Musa acuminata*) is a type of fruit crop that is now widely grown all over the tropical regions and countries and this fruit has a high demand in the market for the consumers all over the world. The banana fruit is categorized as a highly perishable fruit and with this characteristic it possesses, the fruit has suffered a severe post-harvest loss in terms of its quality and quantity [1]. Banana is a climacteric fruit which undergoes physiological changes during ripening process. The ripening of the fruits is caused by either through natural development of endogenous ethylene when the fruit has reached its maturity. This process can also include the use of commercial exogenous ethylene through ripening procedures [2]. The ethylene production of banana shows a rapid increase at the beginning of climateric period [3].

According to [4], attempts have been made to increase the shelf-life of bananas by decreasing its respiration rate through the coating application on the fruits and to slow its ripening stage by anti-ethylene application. Lately, there have been intensive studies made in discovering the new preservative compound that is obtained from a natural resource. For examples are bee wax, paraffin, carnauba, shellac, gums, and chitosan that give no known harmful effects of the human health. It is thought that by coating the fruits with preservative compounds, it can reduce the

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rate of respiration by creating a modified atmosphere that generate a semipermeable barrier against oxygen, carbon dioxide around and within the fruits, thereby retarding the ripening and senescence thus reducing the deterioration rate of the stored fruits and preserving its quality [5]. The main use of edible coating also is for improving the food appearance and also preservation because the compound can provide selective barriers against the decay, moisture loss and respiration.

Chitosan is a polymer that is widely used for coating agent [6]. Chitosan (poly b-(1,4) N-acetyl-D-glucosamine) is a type of polymer that is industrially produced from chemical deacetylation of chitin found in the arthropod exoskeletons or shellfish. This biopolymer also can be found from the cell walls of some plant-pathogenic fungi directly. The chitosan and its derivative have shown in restricting the wide range of fungi growth and activating the defensive mechanism in plants and fruits against the infection by some pathogens. Chitosan possesses incredible film-forming characteristics and this can be applied for edible coating surface in fruits and vegetables. Chitosan coating are reported to limit the fungal decay and delay ripening of some commodities or fruits [7]. At the same time, a chitosan coating significantly reduced the water loss and delayed the changes in color, titratable acidity, ascorbic acid content, and respiration rate in a cultivar-dependent manner. Furthermore, the chitosan is often regarded as the perfect coating preservative for fresh fruit because of its excellent film-forming and biochemical properties. Even though there are some researches were conducted in analyzing the use of chitosan as the preservative in several tropical fruits [8], there should be further research or study conducted on the usage of chitosan coatings in maintaining the quality and extending the shelf-life of the banana fruits during the cold storage processes.

Cold storage is always chosen as a storage for keeping the vegetables and fruit especially bananas before selling them off to the market. The low temperature in the cold storage will help the banana to slow down the process of respiration and ethylene production. As such, the objective of this study is to determine the effect of banana coating stored in the cold storage for a prolonged shelf-life and a better post-harvest quality.

2. MATERIALS AND METHOD

2.1 Location of study

The experiment was conducted in Crop Science Laboratoty and Post-harvest room in Faculty of Plantation and Agrotechnology, UiTM Campus Jasin.

2.2 Preparation of Banana Treatment

The matured and green bananas were used. The banana samples were washed and the dirt was removed. The banana were carefully handpicked and selected to be uniform in appearance (weight, shape and colour). Then the latex was allowed to dry for one hour at an ambient temperature (26 ± 2 °C and 85 ± 5% relative humidity) [16].

2.3 Preparation of Chitosan

The chitosan bought from the market of 5 g, 15 g, and 25 g were dissolved in 900 mL of distilled water. Next, the solution was diluted in 50 mL glacial acetic acid after which the solution will be increased to 1000 ml and then the solution was stirred constantly using the hot plate magnetic

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stirrer until the mixture turns out as a clear color solution. The pH of the solution was adjusted to 5.6 by adding 1 N NaOH and using a pH-meter. The banana then was dipped in the solution for 1 minute for each banana and then were exposed to the room temperature of 25 ^oC.

2.4 Application of chitosan coating on banana

The bananas were applied with the chitosan at 0.5 %, 1.5 % and 2.5 %. Then, after the treatment was applied, the fruits were dried, then placed in plastic plate and labeled. Then the treated bananas were stored at 13 ± 1 ^oC in the cold room for at least 30 days/ until all four (4) fingers of the banana have turned the color from green to yellow. As a control treatment, the bananas that were not applied with chitosan were placed in the cold room whereas another similar set were left out of the cold room at the room temperature.

2.5 Data Collection

The data was collected and analyzed. The quality evaluation of the banana fruit treatment with four different parameters of quality evaluation based on Total Soluble Solid content (TSS) or Brix, Total Acidity (TA) were expressed in the percentage form of Malic acid, while the weight of the banana pre and post treatment and the storage time of the treatment in days were recorded.

2.5.1 Storage Time

The shelf-life of banana fruits as influenced by different percent of chitosan was calculated by counting the days required for them to be fully ripe so that they are suitable to market and consume.

2.5.2 Total Soluble Solid (TSS) content or Brix

The soluble solid content or Brix was measured by using a digital Refractometer. The refractometer was calibrated first with distilled water until the reading was 0. A drop of banana juice or puree was placed in the glass plate of the digital refractometer and then Brix or soluble solid content (SSC) of the banana was recorded.

2.5.3 Total Acidity (TA)

Total Acidity or TA of the banana was measured by using a titration method. The 5ml of filtrated juice from the puree of the banana was used to titrate with 0.1N NaOH mixed with 3 drops of Phenolphthalein solution as an indicator. Then, the solution was titrated to an end point of pink or at least with the pH 8.1 if using the pH meter. Then the initial and final reading of the solution were taken to assess and calculate its acidity of the banana fruit.

2.5.4 Weight Loss

The fruit weight loss was measured using the electronic scale and the weight was taken before and after the treatment.

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3. RESULT

3.1 Storage Time

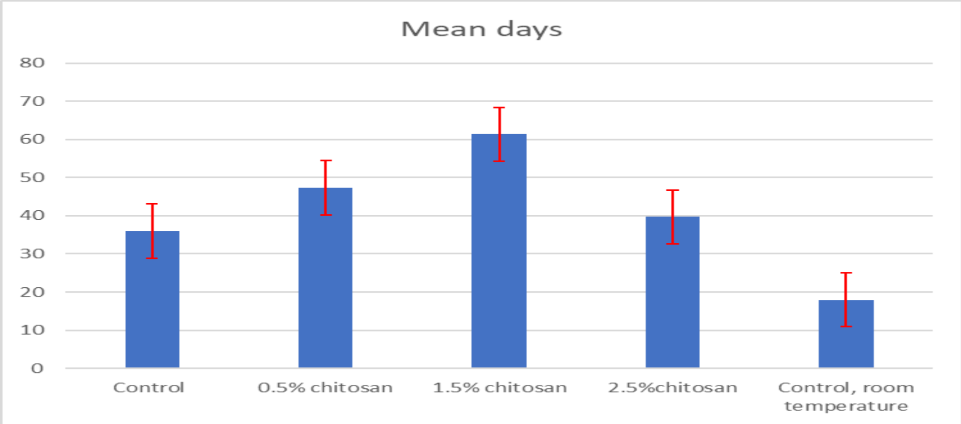

Figure 1: The mean level for storage time in days for banana treatment (3 replication).

Based on Figure 1, it indicates that the storage time was affected by the chitosan application. The treatment for 1.5 % chitosan solution has the highest mean days for storage time which is 61 days. Meanwhile, the lowest mean for the storage time for the uncoated banana treatment in room temperature is 18 days. There is a significant difference between the treatment where the p-value is 0.001 which is less than 0.005.

3.*2 Total Soluble Solid Content (Brix)*

The effect of chitosan application on total soluble solid (TSS) or Brix of banana is shown in Figure 2. The treatment for 2.5 % chitosan solution treatment shows the low TSS and sugar level while the lowest mean for the total soluble solid content of banana is at the control treatment in the cold room with 24 % of Brix mean calculated. The increased level of chitosan coating thickness shows the inhibition of TSS and sugar level. However, the result is not consistent especially for the uncoated banana in cold storage. This is due to the errors during the reading of the data. The p value is 0.56 which is higher than 0.005. Thus, we can sum up that the result is not significant between the control and coated banana (2.5 % chitosan).

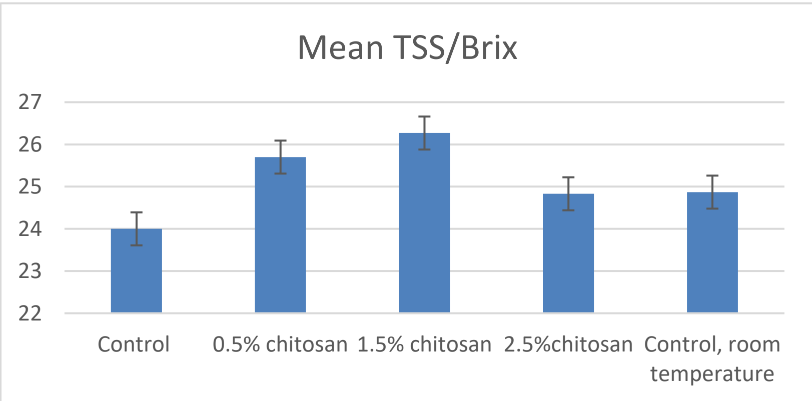

Figure 2: The mean level for total soluble solid content or Brix (sugar level) of banana treatment (3 replications).

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3.3 Total Acidity (TA)

Based on Figure 3, it shows that the different mean between each treatment and the highest mean recorded is at control (uncoated banana in room temperature) treatment with 1.2% acidity while the lowest mean for acidity is 2.5% chitosan treatment with 0.6% of mean acidity for that treatment. The treatment for 2.5% chitosan application indicates that the coated banana can inhibit the metabolic changes of banana but not completely stop the changes. The p value is < 0.05. It means that the result is significant between the treatments. All of the value of acidity is expressed as the percentage of Malic acid content that is the major acidity content in banana aside from citric acid which is another major acid content in banana fruit.

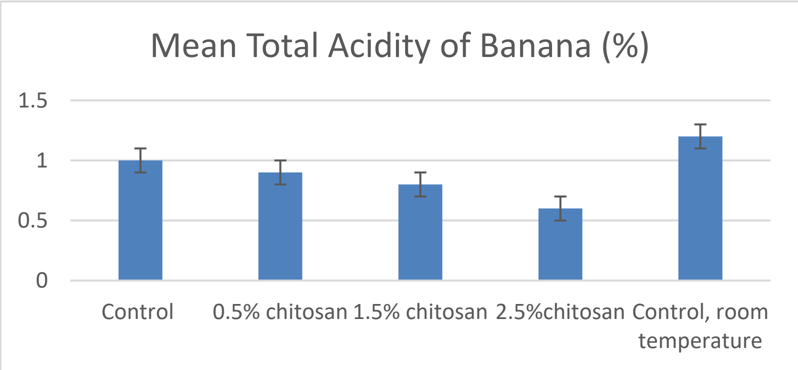

Figure 3: The mean level for total acidity (TA) in percentage of banana in different treatment (3 replication)

3.4 Weight Loss

The graph in Figure 4 shows the percentage of weight loss for all the treatments application on the banana fruit. Statistically significant difference was observed on the percentage of weight loss. The p value is 0.000 which is less than 0.005 and the result is highly significant. The highest loss of weight happens on control (uncoated banana in room temperature) with the loss of about 32 % followed by control (uncoated fruit in cold room), 0.5 % chitosan, 1.5 % chitosan and 2.5 % of chitosan coating. The lowest mean percentage of the weight loss on 2.5 % chitosan was observed. The results indicate that the chitosan coating minimized the weight loss in banana.

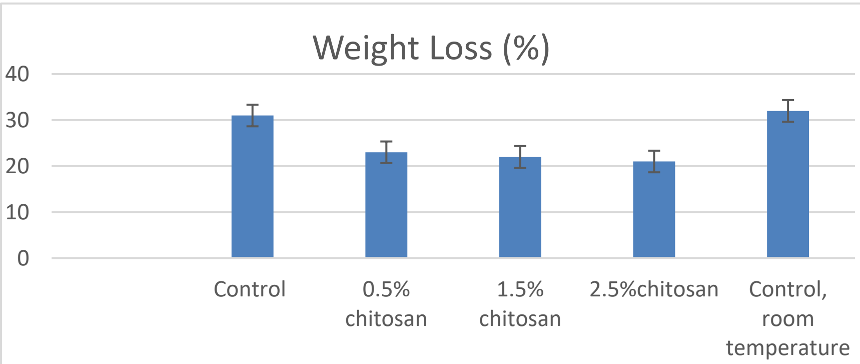

Figure 4: The mean percentage of weight loss of different treatment in grams of banana fruit (3 replication)

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4. DISCUSSION

From the study conducted, the treatment has shown different reactions for the treated banana stored in cold room as well as the control ones in the room temperature. Chitosan treatment at all levels have significantly affected the shelf-life of banana, weight loss, total soluble solid content (TSS) and the total acidity content (TA) of the banana fruit. The treatment using Chitosan has resulted in longer shelf life of banana which can reach 66 days when treated with 1.5 % chitosan treatment. This is because the chitosan coating has an ability in increasing the shelf life of the stored fruits [4]. The coated banana with chitosan will slow down the process of respiration and delay the ripening process. Hence, banana fruit can be stored in a long period compared to the uncoated ones.

Chitosan coatings also reduced the weight loss, and retain firmness and external colour compared to untreated samples [9]. Therefore, the coating has a significant level in maintaining the quality as well as the storage ability of the fruits. A previous study, [10] stated that by increasing the concentration of chitosan it will make the longer period of storage becoming more effective. Meanwhile, [11] also explained that the production of ethylene and carbon dioxide are delayed in coated fruit by chitosan. High ethylene amount in fruit will speed the process of ripening and senescence. However, the chitosan will help to delay the production of ethylene. In another article, [12] reported that chitosan coating will delay the process of ripening as well as slowing down the metabolic changes and respiration in banana. Thus, the chitosan coating proved that it can prolong the shelf-life of fruit during storage without compromising the quality.

For the total soluble solid content (TSS) or Brix of the banana, the significant difference is not really high. The coated banana slows down the production of TSS and TA [18]. The increasing of TSS level in uncoated banana is mainly due to the breakdown of starch to sugar and therefore leads to the decrease in respiration rate and the sugar conversion in H_2O and CO_2. However, the increase in TSS in coated banana after several days was likely due to the internal atmosphere changes in the fruit with the O_2 level decreasing and/or the increase in CO_2 level as well as the inhibition of ethylene production [13]. The application of chitosan coating alone on the climacteric fruit can cause the ethylene in the fruit to be blocked inside and not readily diffused out from the fruit and cause further ripening thus leading to the increased number/ amount in TA and TSS [4]. In the research by Jiang and Li, [10] it was stated that chitosan application will let the bright colour of fruits remain, not rot and also maintain the TSS in a lower temperature of storage. Moreover, [14] also stated that TSS in the chitosan coated fruit was lower compared to the uncoated ones.

As for the total acidity (TA) of the banana treatment, the treatment also shows no significant difference in the total acid content in banana fruit for all the treatment regardless of it being coated or uncoated. The highest total acidity content or TA for the banana is also recorded in 1.5 % chitosan coating treatment at 1.23 % while the lowest total acid content is recorded in control room temperature at 0.67%. The major constituent of acid in the banana fruit is the Malic acid besides the Citric acid which is also another constituent of acid in the banana fruit. Among all the chitosan applied coating treatment on the banana fruit, the 2.5 % coating shows the lowest percentage of total acid content of banana at 0.87 % and 0.5 % coating is recorded at 0.9. Previous study by Jiang and Li [10] stated that total acidity in a fruit that is coated by 2

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% of chitosan is higher compared to the uncoated fruit. It also was proved by El-Ghougth et al.,[11] who reported the same result that TA in 2 % of chitosan coating is the highest.

The fruit weight loss has been observed and recorded and the results show that all the treatments have resulted in weight loss. The percentage of weight loss in control is the highest meanwhile, the weight loss of coated banana (2.5%) is the lowest. It is because the chitosan coating produces a cuticle layer that will retard the water loss [16]. As stated in the previous journal [6], the reduction in weight loss as well as in the vitamin C loss in comparison to the uncoated banana (incomplete structure). Weight loss and vitamin C loss decreased with the increasing of chitosan concentration and degree of deacetylation of chitosan [17] . Gol and Rama, [15] also shows the decreasing number of weight loss of coated banana compared to the uncoated fruit.

5. CONCLUSION

As a conclusion, the chitosan has a high potential to prolong the storage time and retain the quality of the harvested banana. The chitosan is edible and safe for human consumption on any commodities such as fruits and vegetables. In this study, chitosan coating has shown that it can prolong the shelf life of banana stored in the cold storage. At the same time, the application of chitosan coating is able to preserve the total acidity (TA) and total soluble solid (TSS) content of banana fruit. As a conclusion, the percentage at 1.5 % chitosan application is the best treatment for all the parameter and is suggested to be used in order to prolong the shelf-life of the stored banana fruits.

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