The Effect of Starch Proportion in Coating Materials and Storage Temperatures on The Physical Qualities of Curly Green Chili (Capsicum annuum L)

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Abstract: Curly green chili (Capsicum annuum L) is known as one of the very perishable vegetables. Also, some preservation methods were available to be applied, in order to preserve the agricultural products, with the two mostly used techniques being coating and low temperature treatments. This research aims to determine the effect of coating materials and storage temperatures on the physical qualities of curly green chili. In this research, the coating materials with starch proportions of 2%, 4%, 6% and control (without coating), combined with storage temperatures of 5°C and 28°C, were studied, with a factorial design of 4 x 2, and three replications. Furthermore, the total dissolved solid content, firmness, and weight losses, were monitored daily for seven days of storage duration. It was discovered that storage time, temperature, and their interactions significantly affected weight loss. Also, storage time, temperature, and concentration of starch in coating material significantly affected firmness and soluble solid content. However, there was also significant interaction between storage time and temperature, on firmness and soluble solid content. Also, interaction between storage temperature and coating material only affected soluble solid content. Therefore, coating materials with higher starch concentration, produced greater firmness and lower soluble solid content.

Keywords: Coating material, Storage temperature, Physical quality, Chili.

1. Introduction
Horticultural products are easily damaged, as they experience a decline in quality after harvest, which makes them require serious handling treatment. Without proper handling, quality degradation occurs rapidly, and causes a relatively short shelf life. An effort made to maintain shelf life in order to prevent postharvest damage, is by inhibiting the respiration rate of fruits and vegetables [1]. Furthermore, part of the horticultural products requiring postharvest handling for the preservation of its quality longer, is curly green chilies. Curly green chilies are included in the eggplant (Solanaceae) family [2]. Being a non-climacteric product, postharvest deterioration on green chilies is very rapid, and results in huge losses. Moreover, due to high moisture content (60-85%) during harvest, green chilies are also
susceptible to fungal attack [3]. Also, there have been very limited attempts made on the shelf-life extension of green chili, in comparison to bell pepper [4].

Green chilies without any treatment at room temperature last for two to three days, after which they experience withering, with the reduction of weight at 7.5% [5]. Degradation of quality, shriveling with weight loss, change in skin colour, and chilling injury when stored at below 7°C, are the common issues associated with postharvest storing and handling [6]. However, to inhibit wilting and weight loss of chilies, controlled atmosphere storage methods should be applied [1]. Furthermore, this method was discovered to require a very high cost, as another alternative much easier and economical is needed, i.e., the use of coating materials [7]. Edible coating is a thin layer, which is consumed and used, in order to offer resistance to the transfer of gas, water vapour, dissolved materials, and against mechanical damage, while being carried out by immersion, spraying, or brushing [8]. Also, cellulose, gums, starches, and proteins are basic materials used to create edible films and coatings. Moreover, the films developed from starch are described as isotropic, odourless, tasteless, colourless, non-toxic, and biologically degradable [9]. Also, tapioca starch consists of water-soluble polysaccharides, which are often used as a biodegradable film in food industries, due to the fact that it is economical, renewable and provides good physical characteristics [10]. Also, with tapioca starch being an hygroscopic material [11], the ability to absorb water molecules is good, increasing the value of edible film vapour transmission rate produced, and resulting in a strong gel material [12]. The combination treatment between low temperature storage and edible coating is likely to have good potentials in preserving the quality of agricultural products. Therefore, this research aims to determine the effect of coating materials (based on tapioca starch) and storage temperatures, on the physical qualities of curly green chili.

2. Research Methods

2.1. Materials

In this research tapioca starch, glycerol, and distilled water, were the main ingredients to develop edible coating, with the sample materials being curly green chilies, which were obtained from Yogyakarta, Indonesia. In order to be used as the tested material, obtained curly green chilies were cleaned and visually selected, in a bid to locate homogeneity in size, weight, colour, appearance, and freedom from defect and disease. Furthermore, most of the physical properties of these samples were measured prior the experiment, in order to identify the initial condition of the chilies. Also, it was found that the weight of a single chili, length, L*, a*, b*, firmness, and soluble solid content were at 3.0-5.5 g, 8-12 cm, 32.17-37.59, -3.93 to -5.43, 9.33-17.10, 2.24-2.34, and 5.2-5.5, respectively.

2.2. Experimental procedures

In this study, the development of edible coating was carried out based on the Napierata [13] method, with some modifications. The process in producing the edible coating started by making a starch solution of 2%, 4%, and 6% (w/v) in 800 ml of distilled water. These solutions were further added by glycerol, with a fixed concentration of 1% (v/v). Heating of these solutions to a temperature of 70°C or until they were gelatinized was carried out, while being stirred for around 20-30 mins. Furthermore, the solutions were cooled at room temperature for about 20 mins, then they were ready to be applied as the coating materials. The prepared samples of curly green chilies were immersed in the solution individually, and left to dry at room temperature for 24 hours. Afterwards, storage at room and cold temperature of 28°C and 5°C, respectively, should be carried out, when coating material on the chilies' surface have been visually confirmed to be dry. Also, there was a control treatment, as curly green chilies without coating were stored at the same temperatures. Figures 1 and 2 showed the example of curly green chilies' appearance, after being coated and stored at 5°C and 28°C. The measurement of physical parameters consisting of weight loss, firmness, and total soluble solid content, were carried out daily for 7 days of storage period, with three replications for each treatment combinations. Each treatment combinations required around 100 chilies or 500 g in weight.
Figure 1. The appearance of coated chilies with 4% starch concentration at 5°C storage temperature at (a) day 1, (b) day 4, (c) day 7 and (d) day 7 of control treatment

Figure 2. The appearance of coated chilies with 4% starch concentration at 28°C storage temperature at (a) day 1, (b) day 4, (c) day 7 and (d) day 7 of control treatment

2.3. Physical quality measurements

2.3.1 Weight loss
Through the use of a digital balance (Ideallife, IL-500C), the determination of weight loss was carried out by measuring the weight of the same curly green chili daily, with an accuracy of 0.1g and three replications from different samples. Also, weight loss was the difference between the initial and final weights of the sample during storage period, as it was being expressed in percentage. The equation used to determine weight loss was as follows,

\[ WL = \frac{W_0 - W_1}{W_0} \times 100\% \]

WL= Weight Loss (%), \( W_0 \) = Initial weight (grams), and \( W_1 \) = Weight of the next day (grams).

2.3.2 Firmness
Firmness of curly green chili samples were determined using a digital penetrometer (Lutron, FG-20KG), with a cone shaped probe of 6 mm in diameter. A single curly green chili was placed on a flat surface, and compressed with the probe of penetrometer until the cone tip of the device totally penetrated the sample material. Each sample was measured in three different locations, with the average of those values being used in data analysis. Also, this measurement was carried out, using three different samples of curly green chilies.
2.3.3 Total soluble content
Total soluble solid contents of the samples were measured using refractometer (Atago, PAL-α 3840), which had the measurement range of 0-85% brix scale. A single curly green chili sample of about 5 g was chopped and crushed by pounding, until the juice content emerges. This juice is further extracted onto the refractometer lens, trigger the initial process of the measurement. Each treatment combination was measured in three replications, with the average of those values being used in data analysis.

2.4 Statistical Analysis
The experiment was carried out in a completely randomized design of factorial 4 x 2, with three replications for each treatment combinations. The first factor was the starch concentration of the coating material, consisting of 2%, 4%, 6% (w/v), and control without coating, while that of the second was the storage temperature, consisting of 5°C (cold storage) and 28°C (ambient room storage). Furthermore, data analysis was carried out by using the IBM-SPSS ver. 23 software program, in a three-way analysis of variance (ANOVA). Also, mean comparison was conducted by applying DMRT (Duncan’s Multiple Range Test).

3. Results and Discussions
3.1 Weight loss
Figures 3 showed the results of weight loss from all tested samples. It was also observed that the longer the storage time, the higher the weight loss in all the samples. This was caused by the fact that, as the storage period got longer, the water loss from transpiration and respiration of the sample became greater. Furthermore, it was also observed that the weight loss of the coated samples were considerably smaller, compared to that of the control (uncoated chili), for storage temperature at 5°C, for all starch concentrations (p < 0.05). This also indicated that developed coating materials combined with low storage temperature, were capable of reducing water loss from the curly green chili. Moreover, Samira et al. [14] discovered a higher percentage weight loss in peppers stored at ambient conditions, compared to those preserved in the evaporative cooler, which had more air humidity situations. Based on three-way repeated measure analysis (ANOVA), it was discovered that storage time, temperature, and their interactions significantly affected the weight loss (p < 0.05). The rate of weight loss dramatically decreased at 5°C, confirming that storage temperature was an important factor in preserving products quality. Also, the mean comparison analysis (DMRT) was not required, as there was no significant effect of coating materials on weight loss.

![Figure 3](image)

**Figure 3.** The relationship between storage time and weight loss at starch concentrations of (a) 2%, (b) 4% and (c) 6%

3.2 Firmness
Figures 4 showed the firmness value of the samples, which were stored at temperature of 5°C and 28°C. Observations showed that the firmness of the samples decreased with the storage time, as the reduction turned larger for higher preserved temperature. This result was in line with that of Chitravathi et al. [15], which showed that firmness values decreased with storage time, in all chili samples coated and stored in MAP (Modified Atmosphere Storage). Hernandez-Guerrero et al. [16], also discovered
that mango coated with various starch and stored at 10 ± 2°C accompanied at 22°C, consistently exhibited firmness decrease during storage period. Furthermore, the three-way statistical analysis confirmed that storage time, temperature, and concentration of starch in coating materials significantly affected the firmness values of the samples. Significant interaction between storage time and temperature (p < 0.05) was also detected. Also, the DMRT comparison analysis indicated that, aside from the various average values in the view of temperature factor, there was significant difference between mean parameters, according to the coating determinant (p < 0.05). Moreover, coating materials with starch concentration of 4% and 6% also possessed higher firmness values and significant difference to that of the 2% concentration. This was likely caused by the effect of higher starch concentration in the coating material, which possibly offered a better inhabitation on the metabolic activity of the chilies, resulting in a stronger cell wall.

Figure 4. The relationship between storage time and firmness at starch concentrations (a) 2%, (b) 4% and (c) 6%

3.3. Soluble solid content

Furthermore, Figures 5 showed the change in soluble solid content of the samples, for all of treatments. The soluble solid content increased with the storage time, at the temperature of 5°C. This result was observed to agree with that of Hernandez-Guerrero et al. [16], which reported that mango coated with various starch and stored at 10 ± 2°C continued at 22°C, exhibited consistent increase of total soluble solid content during 15 days of storage. According to Winarno [17], the increase occurred because of sugar accumulation, as a result of starch degradation, during the hydrolysis of polysaccharides into simple sugars in the ripening stage. However, the soluble solid content for all coated samples at 28°C was observed to be the largest, which was also consistently larger than the control. This further indicated that at storage temperature of 28°C, it is better to store the chilies without coating. Moreover, coated chilies should be stored at low storage temperature, in order to get the expediency effect of the coating treatment. Furthermore, statistical analysis confirmed that the storage time, temperature, and starch concentration of coating material significantly affected the soluble solid content of the samples. The interactions between the temperature with both storage time and coating material also significantly affected the soluble solid content (p < 0.05). The DMRT comparison analysis also indicated that, besides different average values in view of temperature factor, there was significant difference between the mean parameters, according to the coating determinant (p < 0.05). Therefore, the coating materials with the largest starch concentration of 6%, resulted in the smallest soluble solid content, and significantly differed to that of 2% and 4% absorption.
Figure 5. The relationship between storage time and soluble solid content at starch concentrations of (a) 2%, (b) 4% and (c) 6%

4. Conclusions
It was discovered that storage time, temperature, and their interactions significantly affected weight loss. The weight loss of the coated curly green chilies were considerably small for storage temperature of 5°C, for all of starch concentrations. The storage time, temperature, and starch concentration in coating materials significantly affected firmness and soluble solid content of the samples. Also, there was significant interaction between storage time and temperature, as regards the firmness and soluble solid content. However, the interaction between storage temperature and coating material only affected the soluble solid content. Therefore, the coating materials with higher starch concentration, produced greater firmness and lower soluble solid content.

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References
[1] Megasari R and Mutia AK 2019 J. of Agritech Sci. 3 2 118-27
[2] Waskito H, Nuraini A and Rostini N 2018 J. of Cultiv. 17 2 676-81
[3] Charmongkolpradit S, Triratanasirichai K and Srihajong N 2010 Amer. J. of Appl. Sci. 7 1300
[4] Chitravathi K, Chauhan OP and Raju PS 2015 Food Pack. and Shelf Life 4 1–9
[5] Lamona A, Purwanto YA and Sutrisno 2015 J. of Agric. Eng. 3 2 145-52
[6] Nyanjage MO, Nyalala SPO, Illa AO, Mugo BW, Limbe AE and Vulimu E M 2005 J. of Agric. Trop. et SubTrop. 38 28–32
[7] Novita M, Satriana M, Rohaya S and Hasmarita E 2012 J. of Indonesian Agric. Technol. and Ind. 4 3 1-8
[8] Gennadios A and Weller CL 1990 J. of Food Technol. 44 10 63–69
[9] Krochta JME, Baldwin EA and Carriedo MON 1994 Edible Coatings and Films to Improve Food Quality Lancaster Pa Technomic Publishing
[10] Bourtoom T 2007 J. of Food Technol. 51 2 61-73
[11] Krochta JM and DeMulder-Johnston CD 1997 J. of Food Technol. 51 61–74
[12] Muin R, Malau F and Anggraini D 2017 J. of Chem. Eng. 3 23 191-98
[13] Napierata DM and Alina N 2006 Acta Agrophysica 7 151-59
[14] Samira A, Woldetsadik K and Workneh TS 2013 J Food Sci. Technol. 50 842–55
[15] Chitravathi K, Chauhan OP and Raju PS 2016 J Food Sci. Technol. 53 8 3320-28
[16] Hernandes-Guerrero SE, Balois-Morales R, Palomino-Hermosillo YA, Lopez-Guzman GG, Berumen-Varela G, Bautista-Rosas PU and Alejo-Santiago G 2020 J. of Food Qual. 2020 1-9
[17] Winarno FG 2002 Kimia Pangan dan Gizi Jakarta PT Gramedia Pustaka Utama