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Physicochemical Study of Tejakula Tangerinet Fruit (Citrus Reticulata cv. Tejakula) on the Difference in Edible Coating Concentration to Shelf Life

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ABSTRACT

The success in the effort of developing and distributing Tejakula tangerines is influenced by various factors, one of which is the accuracy of postharvest handling. This is because with proper postharvest handling, the quality of oranges can be maintained and production losses can be reduced. This study aims to determine the storage duration and the most suitable concentration of edible coating to maintain the physical and chemical properties of oranges during storage. This research was arranged based on a Randomized Complete Block Design with a split plot design using two factors and three replications. The main factor is the storage duration with five levels, namely 0 days (L0), 7 days (L1), 14 days (L2), 21 days (L3), and 28 days (L4). The additional factor is the application of edible coating made from sweet potato starch with four levels of concentration, namely without edible coating application (E0), 1.5% concentration (E1), 3% concentration (E2), and 4.5% concentration (E3). The results showed that the storage duration and different concentrations of edible coating had a significant effect on the physicochemical properties of the fruit except for sensory tests of taste, texture, and likability. There was a significant interaction on the physicochemical properties of the oranges in almost all variables except for hardness, moisture content, and Total Soluble Solids with the lowest weight loss at L1E2

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INTRODUCTION

Citrus (Citrus sp.) is one of the fruit commodities that is favored by the Indonesian people. Citrus fruits are known as one of the fruits with a high vitamin C content. One of the local types of oranges developed in Bali is Tejakula tangerine. In order to restore the existence of Tejakula tangerines due to CVPD, the development and distribution of good Tejakula tangerines must continue to be carried out so that the glory of the Tejakula tangerine production area returns.

In the distribution phase, the citrus fruits that reach consumers are expected to be of good quality. The quality of citrus fruits is influenced by garden management (especially nutrient supply) and harvesting activities, also determined by post-harvest handling (Zuhran, 2019). In addition, the length of storage of citrus fruits determines their physical and chemical qualities. Edible coating is an edible wrapping that provides replacement and/or reinforcement to the natural coating on the outer surface of the product to prevent moisture loss, gaseous odor, and movement of substances out of the food, while selectively allowing the controlled exchange of essential gases, such as carbon dioxide, oxygen, and ethylene, involved in the respiration of food products (Embuscado & Huber, 2009). This study aims to determine the shelf life and concentration of edible coating of yellow sweet potato starch raw materials that are best to maintain the physical and chemical properties of citrus fruits during storage.

THEORETICAL REVIEW

Post-Harvest of Tangerines and Quality Changes During Storage

Tejakula tangerines (Citrus reticulata cv. Tejakula) is a local horticultural commodity that has high economic value and development potential, but the quality of the fruit is greatly influenced by post-harvest handling. During storage, citrus fruits continue to undergo physiological processes such as respiration and transpiration that cause decreased weight loss, tissue softening, skin discoloration, decreased water content, as well as changes in chemical components such as total dissolved solids and vitamin C. Research on mandarins shows that improper storage can accelerate the degradation of color, hardness, vitamin content, flavonoids, phenols, and antioxidants, So post-harvest treatment is needed that is able to maintain the quality of the fruit for longer. Therefore, shelf life is an important factor in the physicochemical study of oranges because the longer the storage, the greater the chance of changes in the physical and chemical quality of the fruit.

Edible Coating as a Post-Harvest Technology

Edible coating is a thin layer applied to the surface of the fruit to inhibit water loss, reduce the rate of respiration, reduce gas exchange, and slow down the ripening process. The latest study explains that biopolymer-based coatings can function as a barrier to water vapor and gases so that they can extend the shelf life of horticultural products. In the context of citrus fruits, the use of edible coating has proven to be relevant because mandarin fruits are prone to deterioration during storage. Barsha et al. (2021) found that the coating treatment in mandarins was able to suppress weight loss, maintain juice content, and increase the percentage of market-worthy fruit compared to uncoated controls.

The findings support this study that the application of yellow sweet potato edible coating can affect most of the quality variables of Tejakula tangerines.

The Potential of Yellow Sweet Potato Starch as an Edible Coating Ingredient

Starch is one of the main edible coating materials because it is easy to form a film, is biodegradable, relatively safe, and is available in abundance. Sweet potato starch has the potential as a coating material because it is able to form a layer that can reduce the permeability of water vapor and gases. Ghoshal and Kaur (2023) explain that sweet potato starch can be extracted and utilized in the manufacture of edible film, with functional characteristics that support its use as an environmentally friendly food packaging material. Research by Theamdee et al. (2024) also shows that the combination of sweet potato starch and CMC can extend the shelf life of mangoes, delay weight loss, and slow down the discoloration of fruit skin. This is in line with Tejakula's tangerine research which uses yellow sweet potato starch, CMC, glycerol, stearic acid, and red galangal extract as a coating formulation.

Effect of Edible Coating on Weight Loss and Moisture Content

Weight loss is one of the main indicators of fruit quality decline during storage. This decrease occurs due to water loss through transpiration as well as the use of substrates during respiration. Soto-Muñoz et al.'s (2023) study on mandarins showed that weight loss increased during storage, but fruits given starch-based edible coatings experienced lower weight loss compared to controls without coatings. In this study, L1E2 treatment or one week storage with a concentration of 3% edible coating resulted in the lowest weight loss. This shows that the concentration of 3% is able to form a layer that is quite effective in inhibiting water loss without causing excessive physiological resistance to the fruit.

The Effect of Edible Coating on Fruit Hardness and Skin Tone

The hardness of the fruit decreases during storage due to pectin degradation, softening of the cell wall, and reduced turgor pressure. Edible coatings can slow down this process by suppressing water loss and regulating gas exchange. Soto-Muñoz et al. (2023) reported that starch-coated mandarins showed better hardness than uncoated fruits during storage. In addition to violence, skin discoloration is also an indicator of maturity and consumer acceptance. Research on mandarins with edible coatings based on starch and essential oils shows that coatings can help minimize discoloration during storage. In the Tejakula tangerine study, the treatment without coating changed color faster, while the coating treatment was able to slow down the change in skin color.

Effect of Edible Coating on Total Dissolved Solids and Vitamin C

Total dissolved solids (TPT) generally increase during storage due to the breakdown of complex carbohydrates into simple sugars. The increase in TPT also indicates the ongoing fruit ripening process. In the study of Soto-Muñoz et al. (2023), the soluble value of the mandarin solid content tended to increase during storage, although the effect of coating formulation on TPT did not always differ significantly at each observation time. In this study, the highest TPT was obtained at 28-day storage, while edible coating played a role in slowing down changes in chemical quality. In addition, vitamin C is an important component that is easily degraded due to oxidation. Coatings that are able to suppress oxygen penetration can help maintain the vitamin C content.

Organoleptics and Consumer Acceptance

In addition to physicochemical parameters, the quality of the fruit is also determined by the consumer's acceptance of color, aroma, taste, texture, and level of preference. The use of edible coating must be able to maintain quality without causing a distorted taste or aroma. Soto-Muñoz et al. (2023) show that some mandarin coating formulations are still sensorially acceptable, although certain formulations may give rise to a slight off-flavor after longer storage. Therefore, the selection of coating concentration is important. In this study, the concentration of 3% can be considered a relatively optimal treatment because it is able to suppress weight loss and maintain fruit hardness, without being reported to significantly reduce organoleptic acceptance.

Research Framework of Thought

Based on a literature review, shelf life plays a role as the main factor that affects the physiological and chemical changes of Tejakula tangerine, while the concentration of edible coating plays a role as a post-harvest treatment to slow down the quality degradation process. The longer the storage, the more weight loss increases, the hardness and moisture content decreases, while TPT and skin discoloration tend to increase. Meanwhile, the edible coating based on yellow sweet potato starch is expected to be able to form a protective layer that reduces the rate of transpiration and respiration. Thus, the interaction between shelf life and the concentration of edible coating is important to determine the best treatment in maintaining the physicochemical quality of Tejakula tangerines.

METHODOLOGY

Time and Place of Execution

The research was carried out from July to October 2023. Fruit sampling was carried out at an orange plantation in Penuktukan Village, Tejakula District, Buleleng Regency, Bali Province. The research was carried out in the Ecophysiology laboratory, Agroecotechnology Study Program, Faculty of Agriculture, Udayana University Denpasar.

Materials and Tools

The material used in this study is Tejakula tangerines with the same maturity and taken from the Tejakula tangerine production center in Penuktukan Village, Tejakula District, Buleleng Regency, Bali. The ingredient used for the edible coating formulation is yellow sweet potato starch. In addition, there are additional ingredients such as carboxymethylcellulose (CMC), glycerol, stearic acid, red galangal, and aquades water.

The tools used include scales, choppers, thermometers, trays, penetrometers, hand refractometers, cutting knives, ovens, sieves, measuring cups, containers, brown envelopes, stationery and other supporting chemical analysis tools.

Fruit Sampling

The Tejakula tangerine fruit samples to be used as research materials were taken from the citrus production center in Penuktukan Village, Tejakula District, Buleleng Regency, Bali, with coordinates -8.1531, 115.3853. Sampling will be carried out in July on fruits with yellow fruit skin with a green and uniform tinge. Pick-up is carried out in the morning and transported using refrigerated containers to ensure that the fruit does not deteriorate in quality.

Cleaning and Placement of Fruit Samples

The fruit samples that have arrived at the laboratory are then cleaned of dirt with running tap water until clean, then drained to dry and placed in each test container. The weight of the orange sample of each container is equated to the weight of 1.5 kg. Storage of Tejakula tangerine fruit samples is carried out according to the length of storage at room temperature. Samples were observed to determine the average weight per fruit, weight loss, change in the color of the fruit skin, observation of the moisture content of the fruit, total dissolved solids (0brix), level of hardness of the fruit, consumer preference test (organoleptic test), and vitamin C content test.

Edible Coating Manufacturing

1. Procedure for making yellow sweet potato starch
   a. The sweet potato is cleaned from the remaining soil that sticks to running water then the sweet potato skin is peeled
   b. The cleaned sweet potato is then grated then water is added in a ratio (1:3) or 1,000 gr of sweet potatoes: 3,000 ml of water
   c. The sweet potato porridge is then kneaded so that the starch comes out
   d. The sweet potato pulp is then filtered until water is obtained from the feeling of the sweet potato
   e. Next, the feeling water is deposited for 6-12 hours
   f. The clear liquid at the top of the precipitated juice is discarded while the water deposits are transferred to the tray
   g. The sediment in the tray is then dried in the sun
2. Manufacture of edible coating solution
   a. 1,000 ml of distilled water (Aquades) is put into a homogenized container using a magnetic stirrer at 70°C
   b. Carboxymethylecellusose (CMC) (0.4 % (b/v)) is dissolved in aquades for ±6 min until homogeneous.
   c. Then add starch (according to level) for ±3 minutes until homogeneous
   d. Added glycerol (5% (v/v)) during± 3 minutes until homogeneous
   e. Add red galangal juice (3% (v/v)) for ± 3 minutes until homogeneous
   f. Stirred acid (0.5% (b/v) is added by stirring until it reaches homogeneous stirring for ± 3 minutes

Observation Variables

Weight depreciation (%) is measured by calculating the difference between the weight of the initial sample and the weight of the final sample divided by the weight of the initial sample multiplied by 100%. Weighing is carried out with a digital scale. Observations were made at each level of storage time. The equations used to measure weight loss are as follows:

$$PB = \frac{B0 - Bt}{B0} \times 100\%$$

PB = weight loss (%),
B0 = initial sample weight (g)
Bt = final sample weight (g)

The hardness level of the fruit (N) is measured with a digital fruit penetrometer. To do this, place a probbe or penetrometer needle on the surface of the fruit to be tested. Press slowly and steadily to penetrate the skin of the fruit until it reaches the deep tissue. Then, the hardness value shown by the needle or digital display on the tool reflects the hardness level of the fruit being tested. The hardness level of the fruit is measured at each level of storage time.

The moisture content of the fruit (%) is obtained by cutting the fruit and measuring the fresh weight. After that, it is ovened at a temperature of 80oC, then weighed. If the second weighing achieves a weight reduction of no more than 0.001 g from the first weighing it is considered constant. Then the cup and dry sample are weighed. After that, calculations can be made to find out the percentage of moisture content in the fruit. Measurement of fruit content is carried out every length of storage. The equations used to measure the moisture content of the flesh of the fruit are as follows:

$$Ka\% = \frac{Bb - Bk0}{Bb} \times 100\%$$

Bb = wet weight
Bk0 = oven dry weight

The total dissolved solids (0brix) were measured using a hand refractometer, by squeezing the fruit and then dripping the fruit juice onto the surface of the refractive prism, repeated three times. Point the device at the light source, see and read the numbers listed on the lens, so that the total dissolved solids are large in units (0brix) at each level of storage time.

The vitamin C content was measured by the iodine titration method. The vitamin C content test was carried out at the Laboratory of Agricultural Product Technology, Faculty of Agricultural Technology, Udayana University. Crushed fruit, weighed 5 g. Then it is dissolved to 100 ml by adding aquades, and filtered using filter paper. After getting the citrus fruit extract, take 10 ml and drop it with a 1 ml solution of amylum, then titrate with 0.1 N iodine until it is blue which does not disappear in 30 seconds. After that put it into the formula as follows:

$$\text{Vitamin C}\left(\frac{mg}{100\ g} \quad \frac{\text{iod vol x BE x FP x 100}}{\text{G Ingredients}}\right) =$$

IOD Flight = Volume Iod 0.01 N (ml),
BE = Berat Equivalen = 0,88,
FP = Dilution factor (10x),
g of material = Weight of material (g)

Changes in the color of the fruit skin were measured by observing changes in the whole sample in each experimental unit at each level of storage using a Munsell color chart.

The Consumer Preference Test (Organoleptic test) is carried out using a hedonic test to measure the level of liking color, aroma, taste, texture and level of liking. With this data, statistical analysis can be carried out using 12 selected panelists. During the test, the panelists were shown samples of whole fruit for each experimental unit and the flesh of the fruit to taste. Samples of whole fruit and fruit flesh in a single tasting experimental unit are coded in such a way that the panelists do not recognize and match the coded fruit with the researcher's experimental unit. The level of preference of the panelists based on the organoleptic test was carried out by a scoring test. The likability scale is set from 1 to 5, namely score 1 = extremely dislike, score 2 = slightly dislike, score 3 = neutral (neither dislike or like), score 4 = slightly like, and score 5 = extremely like. Organoleptic tests were carried out at each level of storage time.

Data Analysis

The observation results were analyzed using diversity analysis or Anova (Analysis of Variance) at the level of real influence of 5% and 1%. If there is a real influence (F counts > F table) on the interaction, then it is followed by the Duncan test. If the interaction factor is not real, but a single factor has a real effect, then it is followed with the BNT test of 5%.

RESEARCH RESULTS

The results of the fingerprint analysis showed that there was an interaction between the difference in shelf life (L) and the difference in the concentration of edible coating (E) on the variables of weight loss, vitamin C, organoleptic tests on the indicators of color, aroma, taste, texture, and level of preference, while other variables had an unreal effect. In a single factor, the long shelf life (L) treatment had a real effect only on the variables of fruit hardness, total dissolved solids, weight loss, and moisture content. Likewise, the treatment of the difference in edible coating concentration showed a significant effect on most of the observed variables except for organoleptic tests on taste, texture, and preference level indicators.

Weight loss (%)

Weight loss increases during the storage period. The lowest weight loss was observed in the treatment with a storage time of one week and a concentration of edible coating of 3% (L1E2), while the highest weight loss was recorded in the L4E0 treatment combination of 18.82%. Based on this value, it can be seen that there is an increase in weight loss by 260%. In treatments with a storage time of four weeks (L4), the highest weight loss was observed at each level of E0, E1, E2, and E3. For the four-week (L4) storage period, the highest weight loss was recorded at E0, which was 18.82%, which differed significantly from E1, E2, and E3.

Table 1. Interaction between shelf life (L) and difference in *edible coating* concentration (E) on weight loss (%)

Concentration	Storage Length				
Edible	L0	L1	L2	L3	4
E0	0 h	5,53 g	9,11 f	11.76 and	18,82 a
E1	0 h	5,62 g	9,04 f	11,47 and	15,87 b
E2	0 h	5,22 g	9,22 f	11.96 of	13,42 cd
E3	0 h	5,36 g	8,69 f	12.11 of	14,64 bc

Remarks: Numbers followed by the same letter at the same shelf life show an intangible difference on Duncan's 5% double spacing test.

Fruit Hardness

The hardness of the fruit decreases during storage. In the E0, E1, E2, and E3 treatments, the longer the storage, the less hardness decreases. In the long-term storage treatment, the highest fruit hardness was observed at the L0 treatment of 177.26, which differed significantly from L1, L2, L3, and L4. The percentage reduction in fruit hardness in the long storage treatment is 29.65%. In treatments with different concentrations of edible coatings, the highest fruit hardness was observed at the L2 treatment of 151.39, which differed significantly from E0 and E1. The percentage difference between the lowest hardness (E1 of 141.17) and the highest hardness (L2 of 151.39) in different edible coating concentration treatments was 7.24%.

Table 2. Effect of long shelf life (L) treatment and difference in *edible coating* (E) concentration on fruit hardness

Treatment	Fruit Hardness (N)
Long Stay L0	177,26 a
L1	162,14 b
L2	135,48 c
L3	133,56 c
L4	124,70 c
BNT 5%	15,02
Concentration *of edible coating* E0	141,53 b
E1	141,17 b
E2	151,39 a
E3	150,83 a
BNT 5%	4,34

Description: Numbers followed by the same letter in the same treatment and columns showed an intangible difference on the smallest real difference test (BNT) of 5%.

Fruit Water Content (%)

The water content of the fruit decreases with each treatment during the storage period. In the long-term storage treatment, the highest value was observed at L0 at 88.97%, and the lowest value at L4 at 87.20%, which was not significantly different from L3 at 87.23%. The percentage decrease in water content during storage is 1.99%. For the edible coating concentration treatment, the highest water content was found at E1 at 88.43%, while the lowest water content was found at E0 at 88.01%.

Table 3. Effect of long storage (L) treatment and difference in *edible coating* concentration (E) on fruit moisture content (%)

Treatment	**Until air (%)**
Long Stay L0	88,97 a
L1	88,81 a
L2	88,44 a
L3	87,23 b
L4	87,20 b
BNT 5%	0,58
Concentration of *edible coating*	
E0	88,01 c
E1	88,43 a
E2	88,06 b
E3	88,03 c
BNT 5%	0,29

Description: Numbers followed by the same letter in the same treatment and columns showed an intangible difference on the smallest real difference test (BNT) of 5%.

Fruit Skin Discoloration (%)

The skin color of the fruit at all four concentrations of edible coating treatment changes during storage. Higher values indicate an increasingly orange color of the fruit. The edible coating treatments, both E0, E1, E2, and E3, showed a low value of 2.00 on day 0 of storage, while the highest value of 5.00 was observed in the combination of L4E0 treatments. The percentage of fruit skin discoloration in E0 was 150%, while in E1, E2, and E3 it was 100%, 66.5%, and 50%, respectively. This shows that the color change in the E0 treatment occurs faster compared to E1, E2, and E3.

Table 4. The interaction between the shelf life (L) and the difference in the concentration of *edible coating* (E) on the change in the color of the fruit

Edible Concentration	**Storage Length**				
	L0	**1**	**L2**	**L3**	**L4**
E0	2,00 f	2.33 and	4,00 b	4,00 b	5,00 a
E1	2,00 f	2.33 and	3,33 c	4,00 b	4,00 b
E2	2,00 f	2.33 and	3,00 d	3,00 d	3,33 c
E3	2,00 f	2.33 and	2.33 and	3,00 d	3,00 d

Remarks: Numbers followed by the same letter at the same shelf life show an intangible difference on Duncan's 5% double spacing test.

Total Dissolved Matter (oBrix)

The total dissolved solids in the fruit increased during the storage period for each treatment. In the long-term storage treatment, the highest value was found at L4 of 11.74, which differed significantly from L0, L1, L2, and L3. The percentage increase in total dissolved solids in the long treatment of storage is 20.53%. With regard to the edible coating concentration treatment, the highest total dissolved solids value was found at E0 of 10.70, although it was not significantly different from E2 of 10.67.

Table 5. Effect of long storage (L) treatment and difference in *edible coating* concentration (E) on total dissolved solids (^{o}Brix)

Treatment	**Total Dissolved Solids (^{o}Brix)**
Long Shelf Life	
L0	9.74 d
L1	9,85 D
L2	10,35 c
L3	10,74 b
L4	11,74 a
BNT 5%	0,30
Concentration of *edible coating*	
E0	10,70 a
E1	10,37 b
E2	10,67 a
E3	10,19 b
BNT 5%	0,19

Description: Numbers followed by the same letter in the same treatment and columns showed an intangible difference on the smallest real difference test (BNT) of 5%.

Vitamin C Content (mg/100mg)

The highest vitamin C content was obtained in the combination of two weeks of storage treatment with a concentration of edible coating of 1.5% (L2E1) of 53.39 mg/100g, while the lowest vitamin C content was found in the storage treatment of 0% with a concentration of edible coating 0% (L0E0) of 45.17 mg/100g. At the long-term level of L0 storage, the highest vitamin C content was found in E1 at 48.69 mg/100g, which differed significantly from E0 but did not differ significantly from E2 and E3. At the long-term level of L1 storage, the highest vitamin C content was found in E1 at 51.04 mg/100g, which was not significantly different from E2. At the long-term level of L2 storage, the highest vitamin C content was found in E1 at 53.39 mg/100g. At the old level of L3 storage, the highest value was found in E2 at 49.28 mg/100g.

Table 6. Interaction between shelf life (L) and difference in edible coating (E) concentration on vitamin c content (mg/100 g)

Edible Concentration	Storage Length				
	L0	1	L2	3	4
E0	45,17 f	46.93 and	49,28 cd	48.69 of	48.,11 of
E1	48.69 of	51,04 bc	53,39 a	48.69 of	51,04 bc
E2	46.93 and	48.69 of	51,63 from	49,28 cd	49,28 cd
E3	48.11 of	49,28 cd	49,28 cd	49,87 bcd	48.11 of

Remarks: Numbers followed by the same letter at the same shelf life show an intangible difference on Duncan's 5% double spacing test.

DISCUSSION

The results of statistical analysis using the 5% Duncan test showed that the lowest average weight loss was obtained from the fruit stored during the first week with a concentration of edible coating of 3%. Weight loss is the process of reducing the weight of fruits due to respiration, transpiration, and bacterial activity. Respiration in fruits is a biological process in which oxygen is absorbed to burn organic matter in the fruit to produce energy, followed by the release of combustion products in the form of carbon dioxide gas and water (Pantastico, 1993). The four-week (L4) storage treatment showed the highest weight loss at all edible coating concentrations, with the highest weight loss at E0 of 18.82%. This is consistent with the opinion of Syarif and Irawati (1986) that weight loss continues during storage due to the process of respiration and transpiration. The E2 treatment had the lowest weight loss percentage on the 28th day of storage, which was 13.42%. This is likely because the higher the concentration of starch used, the thicker and denser the edible coating becomes, so that the pores on the skin of Tejakula oranges become smaller, thereby reducing the process of respiration and transpiration. The thickness of the layer affects the permeability of gases and water vapor. The thicker the edible coating, the lower the permeability of gas and water vapor, so that the packaged product is more protected (Rachmawati, 2009).

According to Sukmawaty et al. (2019), weight loss is closely related to water loss in fruits, where the greater the water loss, the greater the weight loss. This is also evidenced by a very significant correlation coefficient (r = -0.86**) between weight loss and fruit water content. The water content of oranges stored in the fourth week (L4) was significantly lower than that of newly harvested fruit (L0). Fruits treated with edible coating with a concentration of 1.5% (E1) showed significant differences compared to 0% (E0), 3% (E2), and 4.5% (E3) treatments, and both factors showed a decrease during storage. The water content decreases along with the transpiration and respiration that the fruit experiences during storage, which leads to water loss.

In addition, the analysis of fruit hardness showed that the highest average fruit hardness was observed in oranges treated with edible coating with a concentration of 3% (E2). This suggests that different concentrations of edible coatings can maintain the weight and hardness of the fruit. Regarding the hardness of the fruit during storage, L1 showed the lowest percentage decrease of 8.53%, compared to L2 of 23.47%, L3 of 133.56%, and L4 of 124.70%. The decrease in hardness of the fruit is due to the conversion of insoluble protopectin into a water-soluble form. The breakdown of protopectin into water-soluble compounds with low molecular weight weakens the cell wall and reduces the cohesion that binds cells together (Naufalin et al., 2011).

Regarding the chemical properties of Tejakula oranges, the storage period can affect the total content of dissolved solids (TPT). The value of TPT tends to increase during storage. The highest TPT content was observed at the four-week storage treatment (L4) of 11.74 oBrix, which represents an increase of 20.53% from L0. The highest TPT content among different edible coating concentrations was found at E0 at 10.70 oBrix, while the lowest at E3 was 10.19 oBrix. This is likely caused by the edible coating that slows down the respiration process, thus delaying the ripening phase of Tejakula oranges. The increase in the total dissolved solids in the fruit occurs due to the formation of simple sugars during the ripening phase. The increase in TPT value in fruit is caused by the hydrolysis of carbohydrates into glucose and fructose (Hidayah, 2009). This suggests that the edible coating treatment effectively forms a sufficient layer to reduce the rate of respiration and transpiration, thereby slowing down the increase in TPT content. By delaying the ripening phase, the quality of Tejakula oranges can be maintained.

The vitamin C content obtained from fruit stored in the second week (L2) was higher than the fruit stored in other treatments. Although the vitamin C content in the second week (L2) had the highest value, according to the 5% Duncan test, the storage period did not significantly affect the vitamin C content of Tejakula oranges. Regarding the concentration of edible coating, fruits treated with edible coating with a concentration of 1.5% (E1) have the highest vitamin C content of 26.69 mg/100g. A similar increase in vitamin C content during storage was also observed by Novita et al. (2016) in crystal guavas, where the increase in vitamin C levels is due to the biosynthesis of vitamin C from glucose in the fruit. This study shows that yellow sweet potato starch-based edible coatings can effectively inhibit the penetration of oxygen into fruit tissues and oxidative reactions that cause vitamin C degradation. This is consistent with Siti (2017's) research, which found that red chili peppers without edible coating (control) had the lowest vitamin C content of 17.36 mg/100g, while red chili peppers coated with ginger-based edible coating (Zingiber officinale) had vitamin content C is 22.19 mg/100g.

CONCLUSIONS AND RECOMMENDATIONS

The results showed that shelf life had an effect on reducing weight loss, fruit hardness, moisture content, and increasing total dissolved solids (TPT). The 0-day shelf life treatment results in the best level of hardness and moisture content of the fruit, while the 28-day storage provides the best TPT value and skin tone score. In addition, the application of edible coating also had a significant effect on most of the observed variables. Edible coating made from yellow sweet potato with a concentration of 3% is able to produce the lowest weight loss and maintain the best fruit hardness during the storage period. The interaction between storage age and the concentration of edible coating of yellow sweet potatoes also had a significant influence on the variables of weight loss, vitamin C content, changes in the color of the fruit skin, and organoleptic taste. The best treatment was obtained in the L1E2 combination, which is storage for one week with a concentration of edible coating of 3%, which results in the lowest weight loss.

FURTHER STUDY

This study still has limitations in the type of edible coating used, observation parameters that are limited to certain physicochemical characteristics, and relatively short storage time. Further research is recommended to develop a combination of other natural edible coating ingredients, evaluate the effectiveness of storage at different temperatures, and add microbiological and antioxidant content analyses to obtain more comprehensive information regarding the quality and safety of fruit during storage. In addition, industrial-scale testing is needed to determine the potential application of edible coating of yellow sweet potatoes commercially in the distribution of Tejakula tangerine.

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