konjac-nano

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Current Research in Food Science

Nanocoating-konjac application as postharvest handling to extend the shelf life of Siamese oranges

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Abstract: Siamese citrus fruit is very popular today, driven by the increasing public demand for healthy food. Siamese oranges contain bioactive phenolic compounds, carotenoids, vitamins, minerals, and fiber which are good for health. The weakness of Siamese oranges is their quality declines quickly and their short shelf life. Postharvest handling with the application of coatings from natural ingredients to extend the shelf life of orange fruits is currently needed to reduce the use of synthetic materials. Natural ingredients that have the potential to be used as base materials for coatings are konjac tubers because they contain glucomannan polysaccharides and bioactive compounds that can form coatings. The purpose of this study was to determine the effect of nanocoating-konjac on the shelf life of Siamese oranges. The research began with the preparation of the nanocoating-konjac formula as the main ingredient of the nanocoating and the application of the nanocoating-konjac on the surface of Siamese oranges. This study used a completely randomized two-factor design, namely nanocoating-konjac application (without coating, coating, and nanocoating) and storage time (0, 5, 10, and 15 weeks), three replications. Variables observed: Weight loss, number of damaged fruits, color, texture, acidity, total soluble solids, water content, vitamin C, and total plate count. The results showed that the application of nanocoating-konjac affected the shelf life of Siamese oranges. This study recommends that the application of 50% nanocoating-konjac with 2 minutes of immersion can maintain the shelf life of Siamese oranges until the 15th day.

Keywords: konjac tuber, nanocoating, quality, shelf-life, Siamese orange

1. Introduction

Consumption of fruits is currently increasing. Public awareness of health indirectly increases the need for quality fruit. Fruits have a variety of specific shapes, sizes, tastes, and textures (Suriati, 2021). One of the fruits that are popular and have high economic value is the Siamese orange (*Citrus nobilis* var. microcarva L) (Darsini et al., 2017). Siamese oranges taste good, they also contain bioactive phenolic compounds, carotenoids, vitamins, minerals, and fiber (Ferreira et al., 2021). The characteristic feature of the Siamese orange is its thin skin (about 2 mm), its surface is smooth, and shiny and sticks to the flesh. The base of the fruit is short-necked with a notched apex. The fruit stalk is short, about 3 cm long, and 2.6 mm in diameter. The flesh is soft with a sweet and fragrant taste. The fruit production is high with a weight per fruit of around 75.6 grams. It is usually harvested in May-August (Darsini et al., 2017). According to (Sulistyo et al., 2019), the bioactive components of phenolics, carotenoids, organic acids, vitamins, and fiber in Siamese oranges are beneficial for health. Besides being delicious to eat, Siamese oranges also function to facilitate digestion, overcome obesity, and increase immunity, as antioxidants, anticancer, and anti-inflammatory (Strano et al., 2021).

The increase in Siam orange production was also followed by an increase in postharvest losses due to improper handling during distribution and storage. A decrease in the quality of Siamese oranges due to mechanical damage of 15-20%, namely in the form of cracks on the skin and rot due to infection by microbial contaminants such as fungi, mold, and bacteria, thus reducing their shelf life (Khorram et al., 2017). The quality of citrus fruit for marketing is influenced by variety uniformity, size uniformity (diameter and weight), maturity level, hardness level, total dissolved solids, total acid, and vitamin C content (Gao et al., 2018) (Saberi et al., 2018). Proper postharvest handling is needed to reduce the decline of Siam oranges, and to extend their shelf life (Sulistyo et al., 2019)(Strano et al., 2021). Therefore, research is needed to maintain the quality of citrus fruits during storage. The coating application method is needed so that the product reaches the consumer's hands and remains of fresh quality (Rasouli et al., 2019)(Suriati, Utama, Harjosuwono, et al., 2020).

The use of coatings from natural ingredients to replace synthetic preservatives is urgently needed. One of the basic ingredients in the manufacture of nanocoatings from the polysaccharide group is glucomannan (Suriati & Utama, 2019)(Azeredo et al., 2022). Konjac (Amorphophallus muelleri Blume) is a potential source of glucomannan. Konjac tubers contain glucomannan or a source of water-soluble fiber which is quite high, namely 79.91% (Yanuriati et al., 2017). Glucomannan from konjac is biodegradable, has antioxidant power, low toxicity, is cheap, and is easy to apply (Srikanth et al., 2019)(Wang et al., 2022). The function of glucomannan is as an emulsifier or emulsifier which is often applied in the food industry because glucomannan can form a gel that has a fairly high viscosity when it is in a liquid (Suriati, Made Supartha Utama, et al., 2020). Glucomannan from konjac also has elastic properties and can form crystals and form fine fiber structures thereby increasing coating properties (Zhou et al., 2018) (Zhang et al., 2020).

Coating ability is affected by particle size and chemical constituents (Suriati, Utama, Harsojuwono, et al., 2020). Particles with a small size (nano) cause a larger surface area resulting in an increase in solubility, release of active compounds, absorption, and attachment (Maria Leena et al., 2020)(Onyeaka et al., 2022). Nanocoating is a nano-sized thin layer that can be incorporated with active additives such as antioxidants, antisenescence, and antimicrobials (Gago et al., 2020)(Correa-Pacheco et al., 2021). The application of nanocoating from natural materials is currently needed to improve the appearance and maintain quality (Suriati et al., 2022), so that it can support the green economy, namely increasing the welfare and social equality of the Siamese orange farming community, while significantly reducing the risk of environmental damage. The advantages of using nanocoating include antimicrobial capabilities, barrier, and mechanical properties, stability of the emulsion system, and adhesion (De León-Zapata et al., 2018)(Sharif Hossain et al., 2018). Nanocoating can be applied to citrus fruits, but there is no research yet.

Nanocoating functions as a barrier to chemical, physical and biological changes (Ghosh et al., 2021)(Hu et al., 2020). The application of nanocoating also improves the appearance of bright and shiny fruit, retains moisture, prevents weight loss, and acts as an antimicrobial (Gago et al., 2020)(Correa-Pacheco et al., 2021). According to (Basaglia et al., 2021), nanocoating helps maintain quality and extends the shelf life of fruits. In line with the opinions of (De León-Zapata et al., 2018)(Ghosh et al., 2021) and (Sharif Hossain et al., 2018), nanocoating can maintain the physicochemical, physiological, and microbiological properties of food so that it can maintain quality, and safety and extend shelf life. Research comparing without coating application, coating application, and application with nanocoating to extend the shelf life of Siamese oranges have no information, further research is needed. The novelty of this research is the effectiveness of the application of konjac-based nanocoating on the shelf life of Siamese oranges. The research objective was to determine the effect of the application of nanocoating-konjac on the shelf life of Siamese oranges.

2. Materials and Method

2.1 Tools and materials

Research tools: refractometer, spectral colorimeter CS-280, viscometer fluorimeter NDJ8S, pH meter, oven, sonicator model Q125 misonix USA, Scanning Electronic Microscope (SEM), Spectrometer UV Vis Libra S60, homogenizer, texture analyzer. Research materials: konjac (Amorphophallus muelleri Blume) aged 6 months and Siam orange (Citrus nobilis Tan) aged 8 months from flowering were obtained from Catur Village, Kintamani District, Bangli Regency, Bali Province. The criteria for the Siamese oranges used: the bottom of the fruit when squeezed feels soft, the color is uniformly yellow and the sugar content is at least 10%. Additives NaCl, Ca (OH)2, and glycerol was obtained at UD. Bharata Chemical Denpasar. This research was conducted at the Food Analysis Laboratory, Faculty of Agriculture, Warmadewa University, Denpasar.

2.2 Research Implementation

Testing the quality of Siamese oranges was prepared as a whole and sorted based on the optimal level of ripeness and each research unit consisted of 30 fruits. The research design used was a factorial complete randomized design. The first factor is postharvest handling, i.e. without coating application, konjac-coating application (non-nano), and nanocoating-konjac application. The second factor is storage time (0, 5, 10, 15 weeks). Variables observed: Weight loss, number of damaged fruits, color, texture, acidity, total soluble solids, water content, vitamin C, and total plate count. The data obtained was tested for diversity with SPSS, if it shows differences the test is continued with Duncan's Multiple Range Test.

2.3 Preparation of konjac flour

The preparation of konjac flour as a basic ingredient for coating and nanocoating-konjac begins with the konjac sorting process, then stripping is carried out to remove the skin. Slicing is done after the washing process, with a thickness of 5 mm. Soaking in 15% salt solution for 30 minutes, after which rinsing was carried out to remove the remaining salt solution. The next process is immersion in 15% Ca(OH)2 solution for 20 minutes. Drying in an oven at 50°C for ±24 hours was carried out after the konjac was drained. The dried konjac slices were ground and then sieved using a 50mesh sieve to obtain konjac flour as the basic ingredient for nanocoating.

2.4 Formulation nanocoating-konjac

Coating-konjac is made by dissolving 1% konjac flour in water. Then, 1% glycerol emulsifier was added, and a homogenization process was carried out for 10 minutes using a heating process carried out at 70 ± 1°C for 5 minutes, then cooled and the konjac coating was ready to be applied. Nanocoating-konjac was prepared by dissolving 1% konjac flour in water, adding 1% glycerol, and then homogenizing for 10 minutes using a sonicate model Q125 to produce nano-sized particles of 200-500 nm. Measurement of nanoparticles using a UV Vis spectrometer. The heating process was carried out at 70+1°C for 5 minutes, then cooled and the konjac nanocoating was ready to be applied.

2.5 Application of coating and nanocoating-konjac on Siamese oranges

Coating and nanocoating-konjac applications were carried out after sorting the Siamese oranges and preparing the experimental units. Each experimental unit was filled with 20 oranges weighing 150-200g each. The dyeing process uses a nanocoating concentration of 50% and an immersion time of 2 minutes. After immersion, it is dried with a blower for 10 minutes, then stored at room temperature. Observations were made periodically on days 0, 5, 10, and 15 which included: Weight loss, number of damaged fruit, color, texture, acidity, total soluble solids, water content, vitamin C, and total plate count.

3. Results and Discussions

3.1 Weight loss

The results showed that the application of the coating showed a very significant effect on the weight loss of Siamese oranges, while storage time and treatment interactions were not different. The highest weight loss value of 33.10% was obtained from the treatment without coating and on the 15th day of storage, as shown in Table 1. The weight loss of Siamese oranges with the application of nanocoating-konjac was also lower than the treatment with the application of konjac-coating. This shows that the nanocoating-konjac treatment was most effective in suppressing the weight loss of citrus fruits. Opinion of Xiao et al., (2021), samples sealed with nanocoating-konjac showed a decrease in weight loss. This is due to the stronger water-retaining properties of the nanocoating-konjac. Non-toxicity properties and high efficiency to preserve fruit, then nanocoating-konjac can be considered a good candidate for commercial coatings.

Table 1. Weight loss of Siam orange

Storage time	Without	Coating	Nanocoating

(day)	coating	application	application
0	00.00	00.00	00.00
5	28.73	18.47	12.47
10	29.70	25.73	23.57
15	33.10	29.27	26.70

3.2. Number of damaged fruit

The results showed that the coating application, storage time, and interaction showed a very significant effect on the number of damaged fruits from Siam oranges. The highest damaged fruit value of 21% was obtained from the non-coated treatment, starting on the 10th day of storage, on day 0 there was no fruit damage in all treatments (Figure 1). The number of damaged Siamese oranges with the application of nanocoating-konjac was the lowest compared to the treatment with the application of coating-konjac and without coating. This shows that the nanocoating-konjac treatment is the most effective in suppressing citrus fruit damage. Opinion (Zhou et al., 2018) that konjac glucomannans coating could maintain the quality of fresh-cut lotus root by the phenolic, a polysaccharide found in glucomannan in konjac, is a polysaccharide that has great potential as a basic material for sustainable packaging, namely edible coatings (Zhao et al. al., 2021).

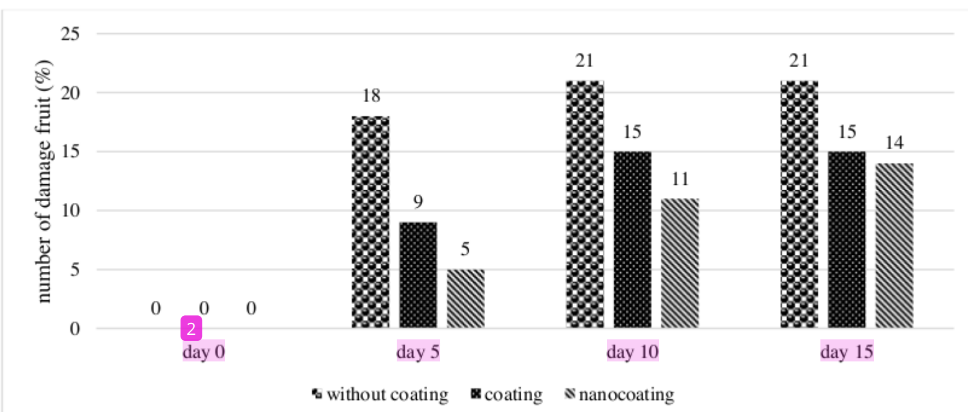

Fig. 1. Number of damages of Siamese orange fruit (%)

3.3. Color

Color is a major key in preferences for food selection and acceptance and even influences taste threshold, sweetness perception, and preferences. The results showed that the coating application and storage time showed a very significant effect on the color of Siamese oranges, while the interaction was not different. The average color value of Siamese oranges ranged from 65.23-89.06, as shown in Table 2. Fruit color increased during 15 days of storage. This indicates that there is a color change from green to yellow due to the ripening process. The nanocoating-konjac treatment produced the lowest color value compared to the konjac-coated and non-coated treatments. The application of konjac nanocoating can delay the deterioration of the quality of Siamese oranges, in other words, it can extend the shelf life. Konjac glucomannan properties can form crystals and form fine fiber structures (Zhou et al., 2018). In addition, glucomannan also has elastic properties, so glucomannan can add to the coating characteristics of konjac (Zhang et al., 2020).

Table 2. Color of Siamese orange

Storage time (day)	Without coating	Coating application	Nanocoating application
0	68.71	65.67	65.23
5	78.44	77.16	86.48
10	88.51	76.64	83.77
15	89.06	74.16	85.60

3.4. Texture

The results showed that the coating application, storage time, and interaction showed a very significant effect on the texture of Siamese oranges. The texture was measured with a texture analyzer using a speed of 5mm/sec and a distance of 20 mm. The texture value of the non-coated treatment continued to increase from 18.25 to 25.09 N, while the citrus fruit with the Konjac-coated and nano-coated Konjac treatments was lower. This means that the surface of the uncoated orange peel dries faster and is harder when punctured with a texture analyzer tool to produce a larger value (Figure 2). The nanocoating-konjac application produces a relatively stable texture value up to 15 days of storage, which ranges from 18.10-19.69N. Nanocoating-konjac can maintain the texture of Siamese oranges during storage. Polysaccharide-based edible coatings have been explored as safe and environmentally friendly food packaging materials (Mohamed, El-Sakhawy, & El-Sakhawy, 2020). These results indicate that coatings can be used to inhibit oxidation (Thian et al., 2022). The water barrier property is due to the increased diffusion of water vapor molecules across the coating. Thus, the coating has a high potential for use in fruit packaging (Xiao et al., 2021).

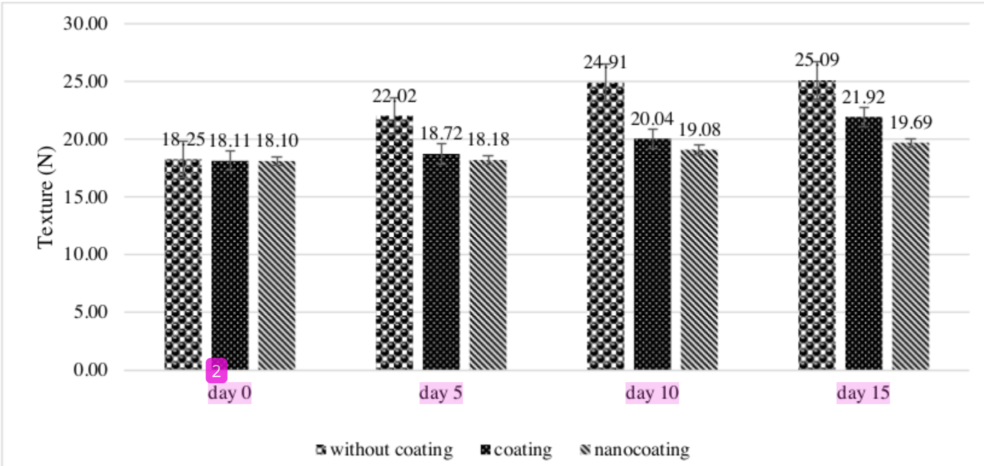

Fig. 2. Texture of Siamese orange

3.5. Acidity

The degree of acidity is one of the important variables that determine the quality of Siamese oranges. The results showed that the coating application, storage time, and interaction showed a very significant effect on the acidity of Siamese oranges. The acidity value of Siamese oranges tended to decrease until the 10th day but increased again on the 15th day of storage, namely between 4.47-4.81, as shown in Figure 3. This occurs due to organic acids being used as substrates for the respiration process. The respiration process still occurs even though the orange has been applied with nanocoating, but the rate is lower. Siamese oranges taste good and contain bioactive compounds such as phenolics, carotenoids, vitamins, minerals, and fiber (Ferreira et al., 2021). Citrus fruit quality is influenced by acidity, variety uniformity, size, ripeness, level of hardness, total dissolved solids, and vitamin C content (Gao et al. 2018; Saberi et al., 2018). Fruit quality parameters such as titratable acidity, total dissolved solids, fruit hardness, ascorbic acid, and skin color can be maintained by coating treatment (Shah & Hashmi, 2020).

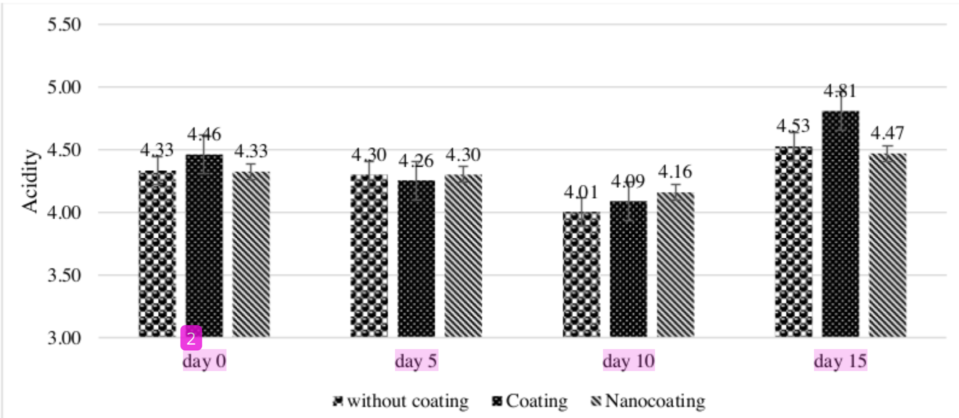

Fig. 3. Acidity of Siamese orange

3.6. Total soluble solids

The results showed that the coating application, storage time, and interaction showed a very significant effect on the total soluble solids of Siam oranges. The total soluble solids value of Siamese oranges without coating increased until the 10th day and decreased again on the 15th day. Meanwhile, the total soluble solids of Siamese oranges with the nanocoating-konjac treatment continued to increase slowly until the 15th day, namely 17.23ºBrix (Figure 4). This shows that the nanocoating-konjac treatment can restrain the rate of respiration so that the breakdown of starch into simple sugars can be suppressed. Thus, ripening and decreasing the quality of Siamese oranges can be prevented. Opinions (Shah & Hashmi, 2020) say that coating treatment can maintain total dissolved solids, suppress disease and maintain the natural properties of fruit during postharvest storage. Supported by the opinion (Suriati, Utama, Harsojuwono, et al., 2020) that coating can extend the shelf life of fresh fruit.

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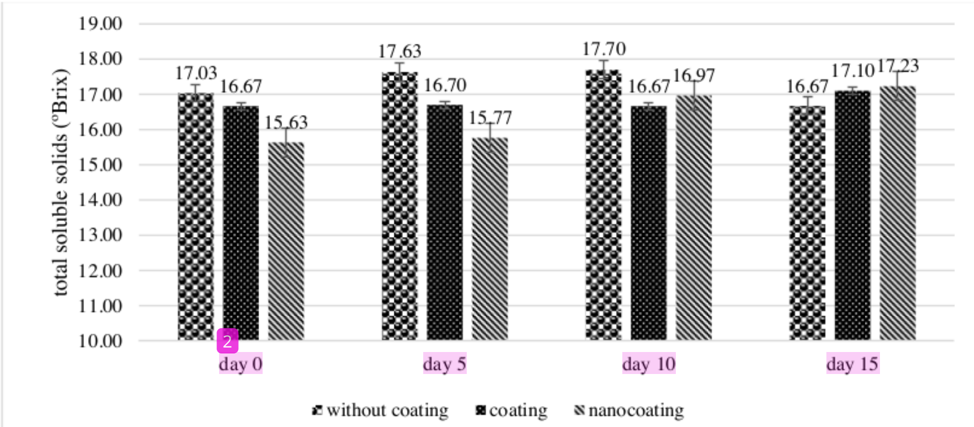

Fig. 4. Total soluble solids (°Brix) of Siamese orange

3.7. Water content

Water content is an important factor affecting the quality of Siamese oranges. The results showed that the coating application, storage time, and interaction showed a very significant effect on the water content of Siam oranges. The average water content of Siamese oranges increased at 5 days of storage, then decreased until the 15th day of storage (Figure 5). This shows that there is an increase in the amount of Siamese orange juice due to the breakdown of starch into simpler components and also water. Moisture content affects the freshness and resistance of ingredients to attack by microorganisms during postharvest handling (Mangkua et al., 2022). According to (Xiao et al., 2021), konjac coatings have the potential to be used in fruit packaging. Konjac glucomannan is a widely used polysaccharide for the preparation of edible coatings with the superior film-forming ability (Xiao et al., 2021). On the other hand, firmness is also closely related to moisture content, as it facilitates the preservation of tissue cell integrity. Zhou et al., (2018) suggested that konjac glucomannan could maintain the quality of fresh-cut fruit.

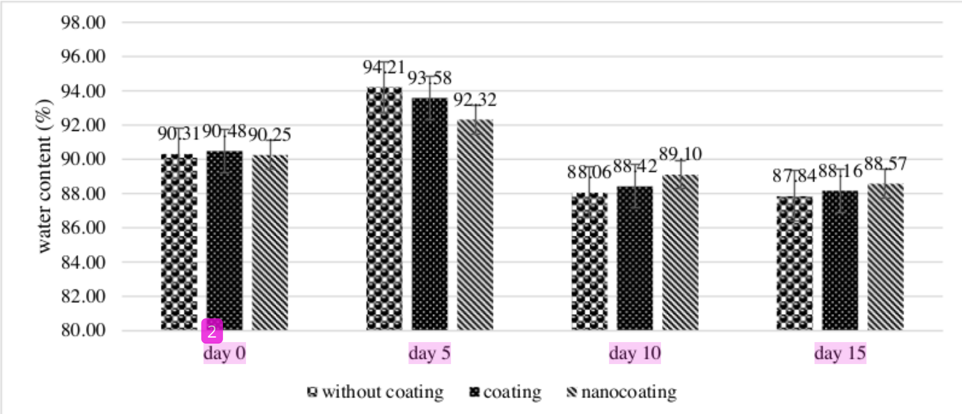

Fig. 5. Water content (%) of Siamese orange

3.8. Vitamin C

The results showed that the storage time treatment had a very significant effect on vitamin C from Siamese oranges, while the nanocoating application and its interaction had no significant effect. The highest vitamin C value of Siamese oranges was obtained in the nanocoating-konjac treatment, namely 73.46 mg/100g, as shown in Figure 6. This means that the konjac nanocoating treatment was able to maintain vitamin C levels of Siamese oranges during 15 days of storage. This shows that the application of the konjac coating can maintain the vitamin C content of Siam oranges. Bagher_hashemi & Jafapour (2021), edible coatings/films based on konjac glucomannan have received more consideration as a promising method to increase the shelf life of fresh kiwifruit. Fruit quality parameters such as titratable acidity, ascorbic acid, and skin color can be maintained by coating treatment (Shah & Hashmi, 2020).

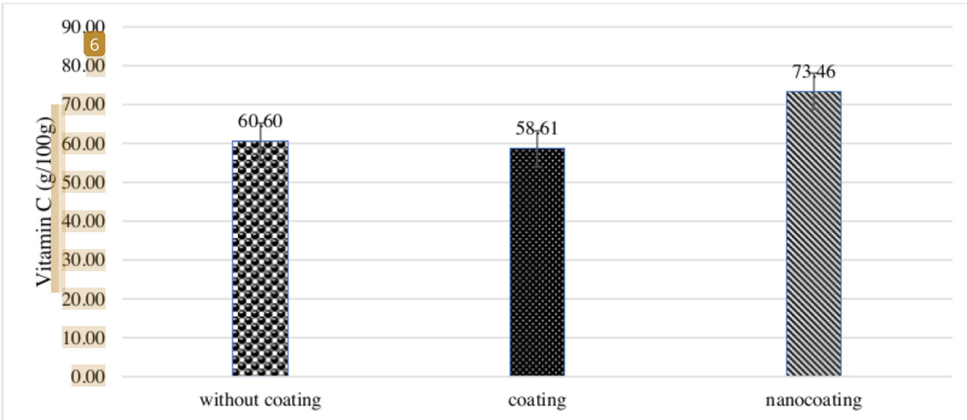

Fig. 6. Vitamin C (g/100g) of Siamese orange

3.9. Total Plate Count

The results showed that the coating application, storage time, and interaction had a very significant effect on the total plate count of Siamese oranges. The highest total plate count value of Siamese oranges was obtained in the non-coated treatment at 15 days of storage, namely 6.89 log cfu/gram, and the lowest in the nanocoating-konjac treatment of 5.68 log cfu/gram, as shown in Figure 7. The increase in total microbes that occurred in week 5 was due to the development of microbes that already exist in citrus fruits and not from the outside environment. Li et al., (2020) also stated that konjac-based coatings showed a more significant and positive effect on ginger quality during storage. Therefore, konjac coatings hold promise in preservation (Xiao et al., 2022). In line with the opinion (Li et al., 2021), these results indicate that polysaccharide-based coatings are very helpful in maintaining the quality of Siamese citrus fruit.

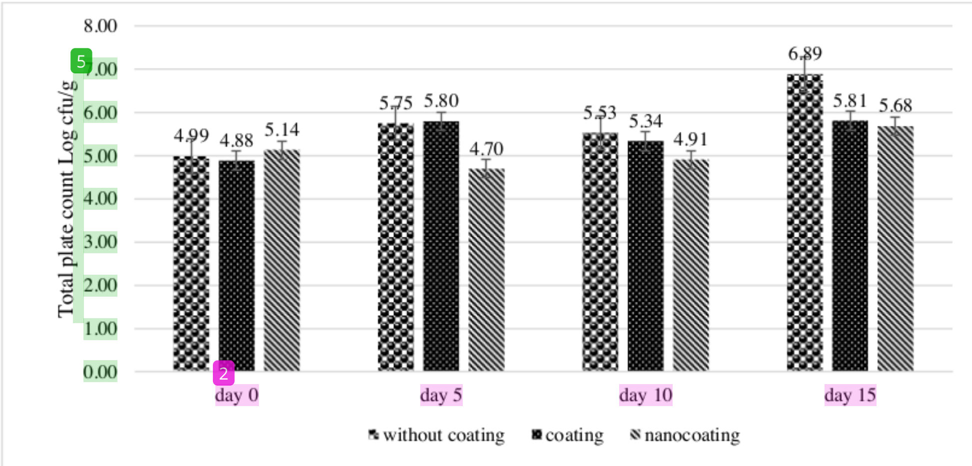

Fig. 7. Total plate count (Log cfu/gram) of Siamese orange

Conclusion

Treatment application of nanocoating on the quality of Siamese orange to determine weight loss, number of damaged fruits, color, texture, acidity, total soluble solids, water content, vitamin C, and total plate count have been studied. The results showed that the application of nanocoating-konjac affected the shelf life of Siamese oranges. This study recommends that the application of 50% nanocoating-konjac with 2-minute immersion can maintain the shelf life of Siamese oranges until the 15th day.

Acknowledgment

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