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Coating Application of Corn Starch and Red Galangal to Extend the Shelf Life of Chrysanthemum Flowers (*Chrysanthemum morifolium*)

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Abstract

Chrysanthemum (Chrysanthemum morifolium) has high economic value. However, fresh chrysanthemums are perishable and have a short shelf life. High respiration and microorganisms are the main causes of quality degradation of chrysanthemums after harvest. The fungus Puccinia horiana causes white rust disease on the leaves which is carried when the flowers are harvested and stored for distribution. Corn starch as an edible coating material combined with red galangal extract is expected to reduce damage by these two factors. The purpose of the research was to determine the best concentration of corn starch and red galangal extract to extend the shelf life of fresh chrysanthemums edible flower. The starch concentration chosen was based on the viscosity of the coating solution which can be applied by spraying and produces the solid and smallest diameter of droplet. The concentration of 2% corn starch coating solution was chosen to be the best solution concentration for coating. In application, the coating solution combination used was 2% corn starch with 1% and 2% red galangal extract, with spraying done once and twice. The results of the study showed that the L2S2 formulation (2% galangal concentration with spraying 2 times) was the best treatment. This treatment can maintain flower water content at 86.02%, weight loss 19.00%, L value 34.50^o, ^{o}hue value 347.04^o on the 6th day of storage with a panelist assessment of a score of 3.25 (freshness, color, aroma). As a comparison, flowers without treatment (control) were still accepted by panelists up to the 3rd day of storage with a score less than 3.

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1. Introduction

Chrysanthemums originating from Chinese land are known as Chrysanthemum indicum (yellow), Chrysanthemum morifolium (purple and pink), and Chrysanthemum daisy (round and ponpon). According to (Han et al., 2017), purple chrysanthemum flowers (Chrysanthemum morifolium) contain high anthocyanin levels. The antioxidant content in chrysanthemum flowers can act as a relaxing agent, cure sore throat, improve vision, prevent fatigue, absorb toxins in the body, and improve blood circulation; therefore, this flower is classified as an edible flower (Yulianti et al., 2019).

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Edible flowers, which can be safely consumed, are non-toxic and have health effects on the human body. Some of the world's famous edible flowers include lilies, chrysanthemums, nasturtiums, roses, tulips, and lilacs. Edible flowers are generally consumed as fresh or processed food (Kou et al., 2012). Edible fresh flowers are perishable and have a short shelf life. One method to maintain the quality and extend the shelf life of fresh agricultural products is to slow down the respiration and transpiration rates that occur when using coatings. Coating is a thin layer of the solution that is applied to the surface of the product as a barrier for gas exchange (O_2 and CO_2) and maintaining product moisture (Misir et al., 2014). Starch is one of the ingredients that can be used as an edible coating.

Corn starch has been widely used as an edible coating because it contains "zein" which can form shiny, scratch-resistant, and fat-resistant films (Maflahah 2015). However, edible coatings made from starch have low resistance to water, which can be a medium for mold growth that damages the product. White rust disease caused by the fungus Puccinia horiana can cause significant leaf damage and reduce flower quality by up to 100% (Suhardi et al., 2007). Therefore, it is necessary to add antimicrobial agents to prevent microbial growth. One of the antimicrobial agents is red galangal. The main component in red galangal is phenol. Phenol compounds that act as antimicrobials have a higher molecular weight, allowing them to easily penetrate the microbial cell membrane and inactivate essential enzymes contained in microbial cells (Tambun et al., 2016). Red galangal extract added to edible coating solutions can inhibit microbial growth in food products (Amalia et al., 2020). Therefore, the purpose of this study was to examine and analyze the effect of using edible coatings made from combination of corn starch and red galangal on the quality and shelf life of chrysanthemum flowers consumed as fresh edible flowers.

2. Materials and Methods

2.1 Materials and Tools

The material used in this study was chrysanthemum (Chrysanthemum morifolium) flowers that were still fresh and had a uniform size, with a harvest age of 9-10 weeks after planting, obtained from edible flower suppliers, namely Pomego Indonesia, located in Tebet, South Jakarta City, Jakarta. The materials used to prepare the edible coating solution were corn starch, red galangal extract, and distilled water as solvents. Red galangal extract in powder form was obtained from BSIP Spices, Medicinal, and Aromatic Plants (Balittro). A magnetic stirrer was used to stir the coating solution, water content test kit to measure the water content of the flowers, a chromameter to measure the color of the flower petals, a hand sprayer with a capacity of 400 ml to apply the coating using the spray method, and a gas analyzer to measure the respiration rate.

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2.2 Diameter and Density Measurement

The droplet diameter and density were measured according to the procedure of Rahayu (2022). The stages used corn starch concentrations of 1%, 2%, and 3%. The corn starch solution was sprayed once on white concord paper measuring 15 × 21 cm in a direction perpendicular to the paper surface from a distance of ± 30 cm. Each coating solution was sprayed on a concord paper with two different nozzle opening, 45° and 90°. The nozzle opening setup used protractor. The concord paper was pinned to the hole of the rack, which was positioned standing. Each treatment was repeated 3 times. The obtained data were processed using ImageJ and Microsoft Excel to obtain the density and diameter of the droplet. The selection of the optimal concentration and nozzle opening was based on the smallest droplet size and density. A small droplet density and size produce an even and compact layer on the surface of the product.

2.3 Solution Viscosity Measurement (Antoni 2021)

Viscosity measurements were carried out at corn starch concentrations of 1% and 2% (selected based on the results of droplet diameter and density measurements) and red galangal extract (in liquid form) 1% and 2% with three repetitions. The falling-ball method was used in this viscosity test. The viscosity value was obtained from the time and distance traveled by the ball. Travel time was calculated using a stopwatch. The ball was placed in a container at a height of 10 cm. The measured viscosity value is in Poise units using the formula in Equation 1.

$$\eta = 2r^2 \frac{(\rho1\text{-}\rho2)g}{9v} \qquad (1)$$

Where: r: ball radius [cm], ρ1: density of ball [g/ml], ρ2: density of the solution [g/ml], g: gravitational force [cm/s^2], v: Velocity of the ball [cm/s]

2.4 Preparation of Edible Coating Solution

The coating solution was prepared from 2% corn starch with 1% or 2% red galangal extract. These concentrations were selected from the 1%, 2%, and 3% concentration tests, which produced the best droplet diameter and density when applied with a hand spayer. Corn starch (2 g) and red galangal extract (1 g) were dissolved in 97 g of distilled water to produce 100 ml of a coating solution of 2% corn starch and 1% red galangal extract. To produce 100 ml of a solution containing 2% corn starch and 2% extra red galangal, 2 g of starch and 2 g of extra galangal were dissolved in 96 g of distilled water. To produce a homogeneous solution, stirring was performed using a magnetic stirrer for 60 minutes at 1000 rpm and 60 ^{o}C.

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2.5 Application of Edible Coating on Chrysanthemum Flowers

The coating solution was prepared from 2% corn starch with 1% or 2% red galangal extract. These concentrations were selected from the 1%, 2%, and 3% concentration tests, which produced the best droplet diameter and density when applied with a hand spayer. Corn starch (2 g) and red galangal extract (1 g) were dissolved in 97 g of distilled water to produce 100 ml of a coating solution of 2% corn starch and 1% red galangal extract. To produce 100 ml of a solution containing 2% corn starch and 2% extra red galangal, 2 g of starch and 2 g of extra galangal were dissolved in 96 g of distilled water. To produce a homogeneous solution, stirring was performed using a magnetic stirrer for 60 min at 1000 rpm and 60 ^{o}C.

2.6 The Measurement of the Quality Parameter and Quality Analysis

2.6.1 Rate of Respiration

The respiration rate was measured using the closed method. The respiration rate was calculated based on changes in O_2 concentration in a 260 ml chamber containing flower samples. The chamber containing the samples was kept in a refrigerator at 10 °C for 24 h. After 24 h, the respiration rate was measured. Measurements were taken every day for six days of storage at the same time. The process of opening and closing the container for ± 15 min was used to normalize the gas composition of the container. The respiration rate was calculated using Equation 2.

$$R_1 = \frac{v}{W}\frac{dx_1}{dt} \qquad (2)$$

Where: R: respiration rate [ml kg^{-1} h^{-1}], x: O_2 gas concentration, t: time [hours], v: free volume of respiration chamber [ml], W: product weight [kg]

2.6.2 Water content

The water content was measured using the gravimetric method (OAOC 2005), using Equation 3.

$$Wc\% = \frac{w_1 - w_2}{w_1} x\ 100\% \qquad (3)$$

Where Wc is Water content [%], w_1 is the initial sample weight [g], and w_2 is the final sample weight [g].

2.6.3 Weight Loss

Weight loss measurements were performed daily during storage, starting from day 0 to day 7. Weight loss in flowers was measured using an analytical balance until the shelf life was determined by measuring the respiration rate in the previous stage. Equation 4 was used to calculate the weight loss:

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$$WL = \frac{w - w_i}{w} \times 100\% \quad (4)$$

Where: WL: weight loss [%], w: initial weight [g], w_i: final weight [g]

2.6.4 Color

The color intensity of chrysanthemum flowers was measured using a chromameter. Measurements were taken on the three outer sides of the petals every day during storage. In this Chromameter, the L, a, and b color systems are used. The a and b values were processed to produce °hue values using Equations 5 and 6.

$$°hue = \arctan\left(\frac{b}{a}\right) \quad (5)$$

$$°hue = \frac{\left(\mathrm{Tan}^{-1}\frac{b}{a}\right) \times 360}{2\pi} \quad (6)$$

Where: a: red color [positive], green color [negative], b: yellow [positive], blue [negative]

2.6.5 Organoleptic Test

Organoleptic tests were conducted to determine the shelf life of the edible chrysanthemum flowers. Thirty panelists were used for the organoleptic tests. The edible flower parameters tested organoleptically were color, freshness, and aroma. The test was conducted in two stages, namely 10 people (semi-trained) directly with three test criteria (freshness, color, and aroma) and 20 people (untrained) visually in the form of photos with test criteria (freshness and color). All parameters tested were given a score range of 1-5 with a consumer acceptance limit of 3.

2.6.6 Total Plate Count Analysis (TPC)

TPC analysis was performed according to the SNI 2897:2008 procedure. A total microbial test was performed using the pouring method. The dilution tested in the pour method was 10^{-3} dilution and analyzed three times. Mixing between the sample and the media was performed by pouring ± 1 ml of the dilution solution on a Petri dish, and then adding ± 20 ml of Plate Count Agar (PCA) media. Samples and media that had been mixed were stored in an incubator (temperature ± 37 °C, for ± 48 h). The final stage involved counting the colonies that grew on the media. The calculation of microbial colonies was carried out based on TPC for two days after the sample incubation period using the formula in Equation 7.

$$TPC = JK \frac{1}{FP} \quad (7)$$

Where: JK: Number of Colonies; FP: Dilution Factor

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2.6.7 Experimental design

The experimental design used in the preliminary research to select the concentration of corn starch was a completely randomized design (CRD). The concentration treatment and measured parameters were the droplet density and droplet size. The experimental design for coating application was a completely randomized factorial design (CRF) with two factors. The first factor is the concentration of red galangal at two levels (1% and 2% concentration) and the number of sprays (one spray and two sprays) with three repetitions. The number of experimental units was four combinations of coating treatments and one control with treatment codes: L1S1 = 2% corn starch, 1% red galangal extract with 1 spray; L1S2 = 2% corn starch, 1% red galangal extract with 2 sprays; L2S1 = 2% corn starch, 2% red galangal extract with 1 spray; L2S2 = 2% corn starch, 2% red galangal extract with 2 sprays; and K1 = treatment without coating (control).

2.6.8 Data Analysis

The data obtained were processed statistically using Analysis of Variance (ANOVA); if the treatment had a significant effect on the results, Duncan's Multiple Range Test (DMRT) was conducted with a confidence level of 95% (α = 0.05). Analysis of variance and Duncan's further tests were conducted using IBM SPSS 24 software.

3 Results and Discussion

3.1 Droplet diameter and density measurement

Droplet diameter and density were key parameters in spray-coating applications. The expected characteristics were a small droplet diameter and high density. The DMRT test results for the droplet diameter and density of the corn starch solutions with the three concentrations tested were presented in Table 1. The DMRT test results for the nozzle opening of the cornstarch solution were presented in Table 2.

Table 1. DMRT test results of diameter and droplet density of corn starch solution

Concentration	Droplet Diameter (µm)	Droplet Density (Total/100 cm^2)
1%	151.82±18.79^{a}	279.77±90.26^{b}
2%	157.01±14.63^{a}	234.22±23.75^{ab}
3%	177.07±8.09^{b}	172.78±67.32^{a}

Table 2. Yield instead of corn starch solution nozzle

No Nozzle	Droplet Diameter	Droplet Density (Total/100cm^2)
45^0	160.58±10.81[a]	265.94±58.67[b]
90^0	163.35±23.26[a]	191.91±77.95[a]

Tables 1 and 2 showed the results of droplet diameter with a high concentration of corn starch coating; a large nozzle opening produces the highest diameter size while the density was low. The ANOVA results showed that the concentration of the cornstarch coating solution was significantly different from the droplet diameter and density of the droplets produced. For the nozzle opening treatment factor, the droplet density also showed a significant difference.

Based on the results of further tests (DMRT) on the droplet diameter factor, the 3% treatment was significantly different from the 2% and 1% treatments. Meanwhile, the droplet density factor showed that the treatment with a 3% concentration was significantly different from the 1% concentration treatment. However, the 2% concentration was not significantly different from the 1 and 3% concentrations. Table 2 lists the average result of the nozzle opening with a low droplet diameter and high density produced at the 45° nozzle opening. The selected corn starch concentration was 2% with spray application using a nozzle opening at 45° positions because it produces a value with a small diameter but a high density.

3.2 Rate of respiration

Respiration rate is one of the parameters that plays an important role in determining the type of postharvest handling of agricultural products. The respiration rate of chrysanthemum flowers, as indicated by the O_2 consumption rate during storage, was shown in Figure 1.

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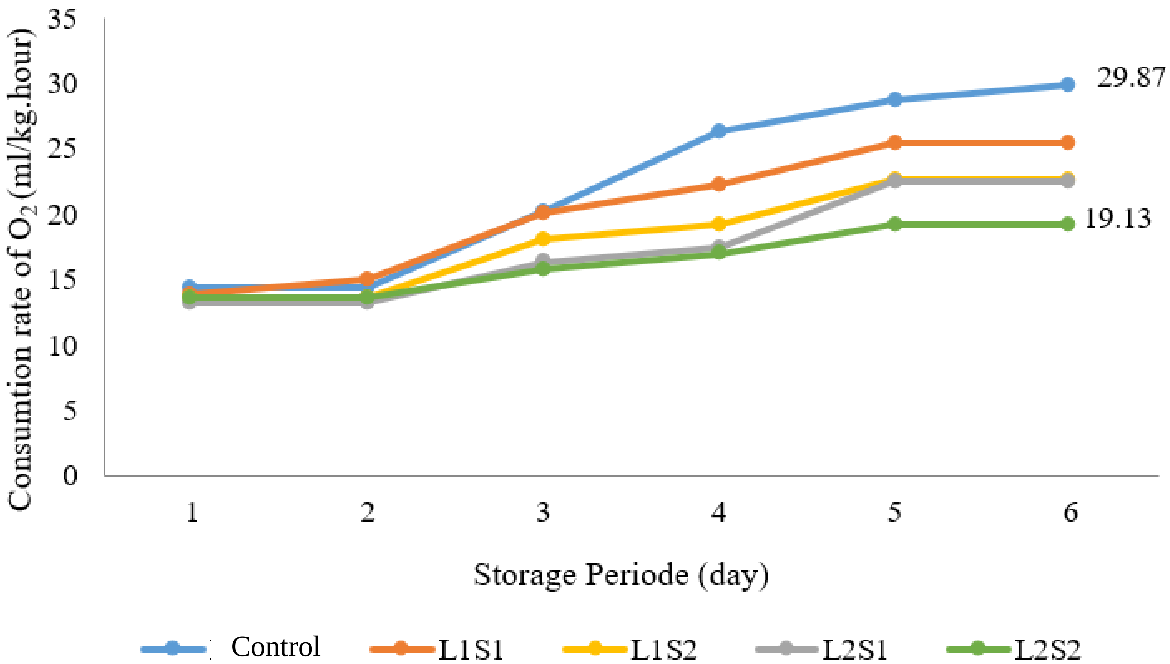

Figure 1. O_2 consumption rate of chrysanthemum flowers during storage period

Based on the results of the study in Figure 1, the average O_2 consumption rate of chrysanthemum flowers increased during the storage period. The rate of O_2 consumption on day 6 with the lowest value was chrysanthemum flowers with 2% corn starch coating treatment and 2% red galangal extract with 2 sprays (L2S2) which was 19.13 ml kg^{-1} h^{-1} while the control has reached 29.87 ml kg^{-1} h^{-1}. ANOVA results showed that the concentration of red galangal extract affected the O_2 consumption rate. This effect was observed from day 4 until the end of storage. The number of sprays also affected the O_2 consumption rate, which began to appear on day 5. Further test results (DMRT) showed that the 1% red galangal extract concentration was significantly different from the 2% concentration, and both were significantly different from the control. (Nurlatifah et al., 2017), based on their research, stated that Langsat fruit coated with edible coating with the addition of red galangal extract can inhibit the respiration rate. One of the factors that increases the respiration rate was damage to the flowers due to microbes. The addition of extra red galangal to the coating can inhibit microbial damage. The application of coating with sprays two times (L2) forms a more even layer that allows the stomata on the flower petals to close better so that there was a limit to the entry of O_2, which results in a decrease in the respiration process.

3.3 Water content

The water content of food ingredients greatly affects their shelf life and quality of food ingredients. The measurement results in Figure 2 showed that the number of flowers without treatment (control) began to decrease from the 1st day of observation compared to the coating treatment, which showed a decrease from the 3rd day of observation. The moisture content of chrysanthemum flowers with coating treatment after 6 days of storage ranged from 81.65% to 86.02%, whereas in chrysanthemum flowers without coating treatment (control), it was 79.75%. ANOVA results showed that the concentration of red galangal extract as a coating influenced the change in moisture content, and the effect was observed from the fourth day until the end of storage (day 6). The part from the transpiration process, the decrease in moisture content was also caused by damage, one of the reasons was microbial damage. With the addition of red galangal extract, microbial development can be inhibited, so that damage due to microbes was low, which has an impact on the decrease in water content.

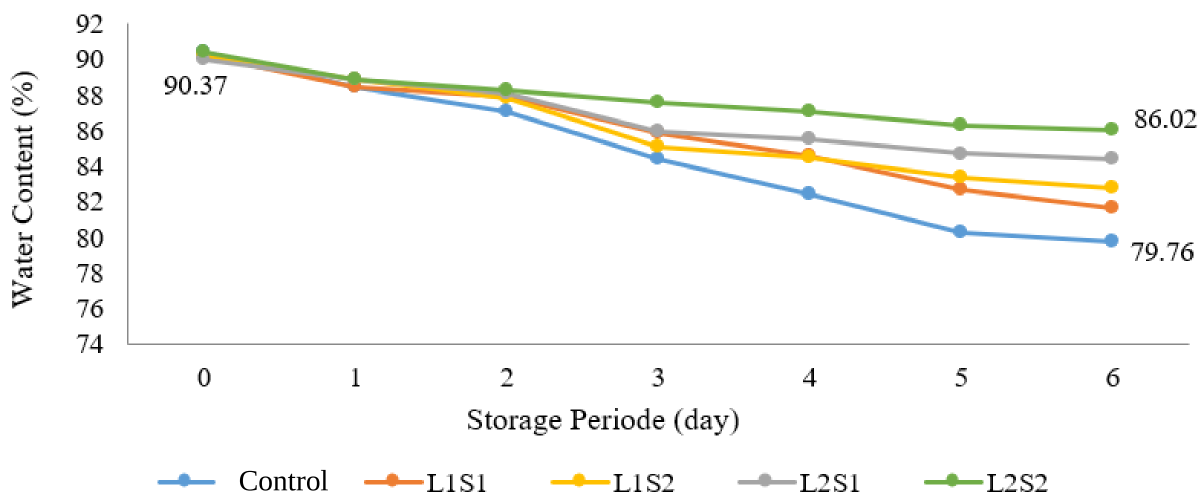

Figure 2. Moisture content of chrysanthemum flowers during storage period

Further tests (DMRT) showed that the water content in the coating treatment combined with 1% red galangal extract was different from the 2% treatment, and both treatments were different from the control. At the end of storage, the water content of chrysanthemum flowers treated with L2S2 remained at 86.02% from the initial value of 90.37%, while the control showed the highest decrease, so that at the end of storage, the water content was 79.79%. The addition of 2% extra galangal to the coating made from 2% corn starch was better at maintaining the water content of chrysanthemum flowers than addition of 1% extra galangal. The use of edible corn starch coatings with the addition of red galangal extract, which was antimicrobial in nature, can increase the stability of edible coatings, thereby increasing their ability to inhibit the rate of water vapor (Wisudawaty et al., 2016). Meanwhile,

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the effect of the number of sprays on moisture content on each day of storage was not observed. ANOVA indicated that there was no significant difference between the treatments and the control.

3.4 Weight Loss

One consequence of a decrease in flower moisture content was an increase in flower weight loss during storage. Based on the measurement results in Figure 3, the increase in weight loss began to occur from day 1 to day 6 of storage, and flowers that experienced the highest weight loss increase on the 6th day of storage were untreated flowers (control) with a weight loss value of 29.77%. The treated flowers had a weight loss value of 19–26.05%, with the lowest value being the L2S2 treatment.

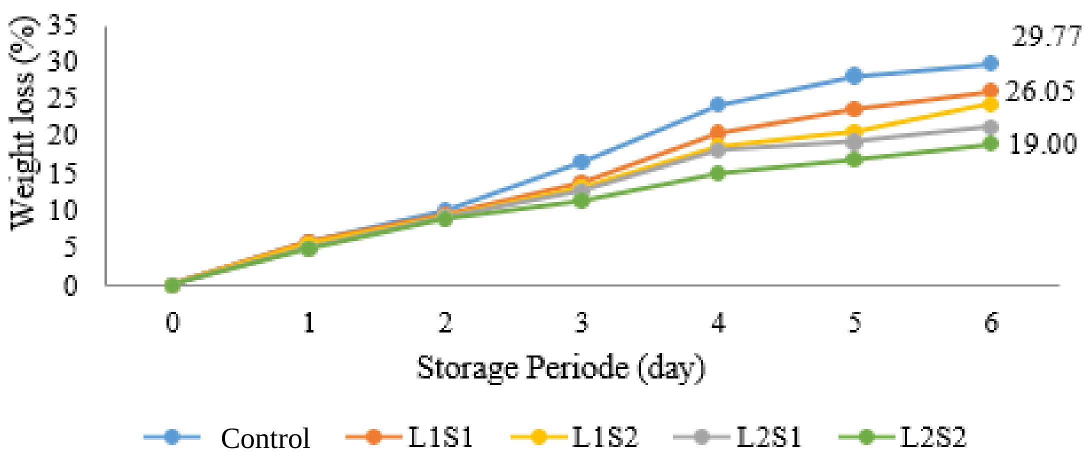

Figure 3. Change in weight loss value (%) of chrysanthemum flowers during storage period

The concentration of red galangal extract added to the coating solution (2% corn starch) affected weight loss. The effect was observed on day 4 until the end of storage, when the 1% red galangal extract treatment was significantly different from the 2% concentration, and both treatments were also significantly different from the control. The number of sprays did not affect the weight loss between treatments (spray 1 time and spray 2 times) but was different from that of the control flower. These results indicate that the use of edible corn starch coating with the addition of red galangal extract, which was antimicrobial agent, can reduce the rate of weight loss. One of the causes of weight loss was the damage caused by microbes. Antimicrobials can reduce the weight loss caused by microbial damage. Weight loss was defined as the process of reducing the amount of water or weight of the fruit due to respiration, transpiration, and microbial activity (Ayu et al., 2020). The coating forms a thin membrane on the surface of chrysanthemum petals as a barrier layer to inhibit flower metabolic reactions in the form of respiration and transpiration. Amalia et al., (2020) stated that the addition of

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galangal extract to banana fruit edible coatings can minimize weight loss due to low oxygen consumption and reduce water transpiration.

3.5 Color

Color was a measure of the quality of food products. Color can also indicate the freshness of a food product. Color measurements were carried out using a chromameter, which produces L, a*, and b* values. According to (Alotaibi et al., 2021), the CIE L*a*b* color system describes colors based on three basic colors: red, green, and blue. The changes in the L value of chrysanthemum flowers during shelf life were presented in Figure 4.

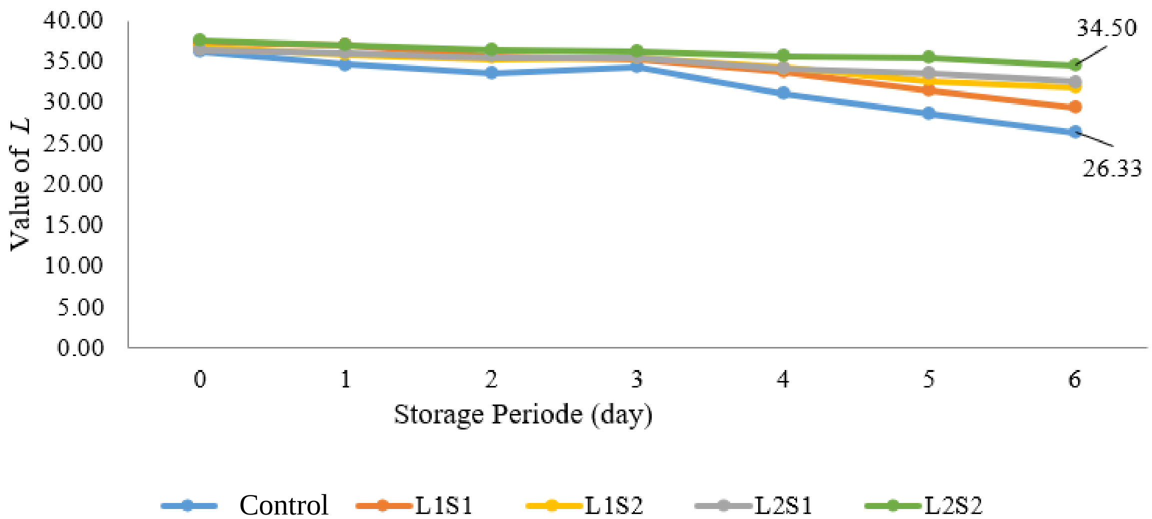

Figure 4. Changes in L-value of chrysanthemum flowers during shelf life

Figure 4 showed that the changes in the L value of chrysanthemum flowers decreased with the length of storage time. The highest decrease during the storage period in chrysanthemum flowers was found in flowers without treatment (control), whereas on day 0 the value of 36.22 decreased to 26.33 at the end of storage (day 6). The ANOVA results indicated that there was an effect of extra galangal concentration and the number of sprays on flower color changes during storage. The effect of the two factors (concentration of red galangal and number of sprays) was observed from day 5 until the end of storage (day 6). DMRT further test showed that 2% concentration resulted in a decrease in L value that was different from 1%, and both had different L values with control flowers from day 5 of storage. Likewise, the number of sprays resulted in different L-values for one spray and two sprays, and both were different from the control. The results of further tests (DMRT) of the red galangal extract coating treatment factor and the number of spraying factors on changes in the L value from day 5 to day 6 were significantly different for all treatments.

The change in the °hue value was in line with the L value due to changes in the color of the chrysanthemum petals. The changes in the °hue value of chrysanthemum flowers during shelf life were presented in Figure 5.

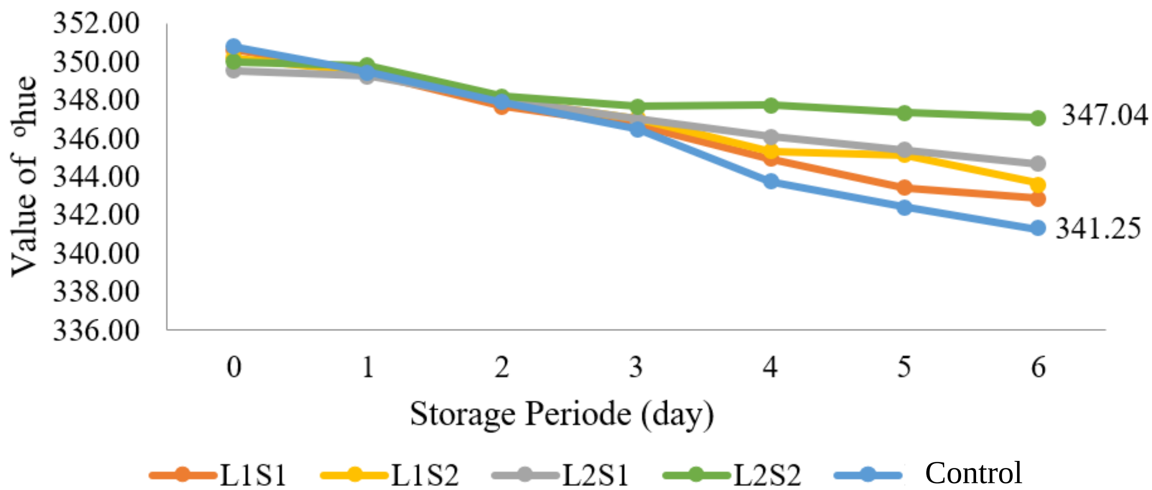

Figure 5. Changes in °hue value of chrysanthemum flowers during shelf life

Control chrysanthemum flowers decreased by 9.50° (initial L 350.75°, final L 341.25°), while chrysanthemum flowers that received L2S2 treatment decreased by 2.92° (Lawal 349.96°, final L 347.04°) after 6 days of storage. The best treatment with the most stable change in °hue value was the treatment with the L2S2 formulation, and these results were significantly different from other treatments and controls based on ANOVA results. The effect of concentration and amount of spraying on changes in °hue value during storage was observed starting on day 4 of storage and continued until the end of storage, based on the results of further tests (DMRT). Coating with the L2S2 formulation can be considered as the best treatment for maintaining the °hue value. The coating formed can limit the interaction with the O_2 environment, so that the oxidation process of anthocyanins can be inhibited, resulting in a slow color change.

3.6 Organoleptic test

Organoleptic tests were conducted to determine the level of consumer acceptance of chrysanthemum flowers that had been given a coating solution. The parameters observed and scored in this organoleptic test were freshness, color, and aroma. The organoleptic tests were conducted by 30 panelists. Changes in the panelist's scores for the freshness quality of chrysanthemums during storage were presented in Figure 6.

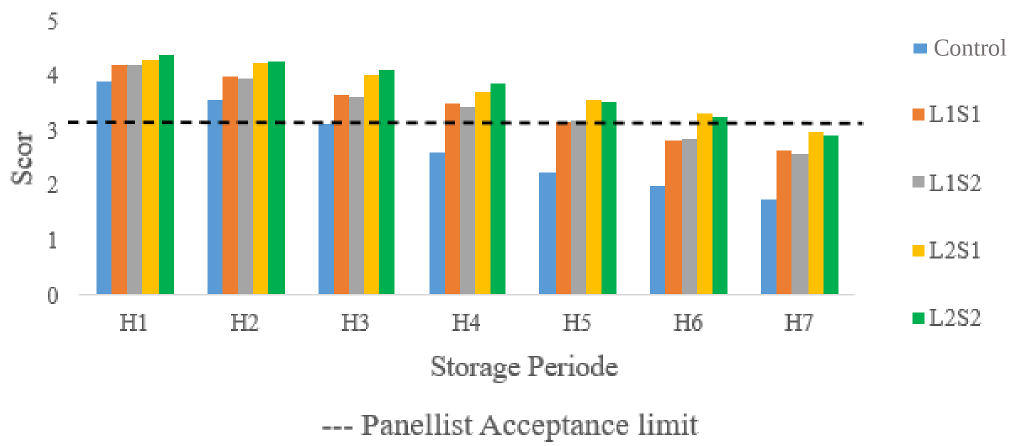

Figure 6. Changes in panelist's scores of chrysanthemum flower freshness during storage

Figure 6 showed a decrease in panelist's preference for chrysanthemum flower freshness. Based on the panelist's scores, the flowers treated with L2S1 and L2S2 were still accepted by the panelists until the 6th day of storage, whereas the control flowers only reached day 3. After six days, all treatments were no longer accepted by the panelists (scores below 3). Flower freshness is closely related to turgor pressure. Adequate moisture content in flower cells helps to maintain turgor pressure. As the moisture content decreases, the turgor pressure decreases, causing flower cells to wilt and become flaccid. The moisture content of flowers treated with S2 (two sprays) was higher than that of the flowers treated with one spray. A more complete coverage of the petal surface indicates that water loss due to transpiration can be inhibited. The moisture content of flowers treated with S2 was higher until the end of storage. The panelist's scores on chrysanthemum flower color during storage were presented in Figure 7.

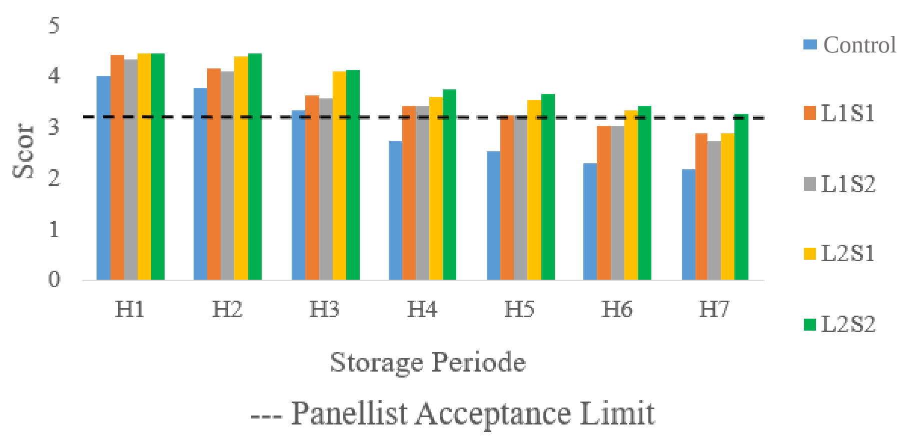

Figure 7. Changes in panelist's scores of chrysanthemum flower color during storage

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Like freshness, the color of flowers treated with L2S2 was acceptable to panelists until the 7th day of storage with a score of 3.26, while flowers that did not receive treatment (control) were no longer acceptable to consumers on the 4th day because their score was below 3. Meanwhile, the score for aroma during storage were shown in Figure 8.

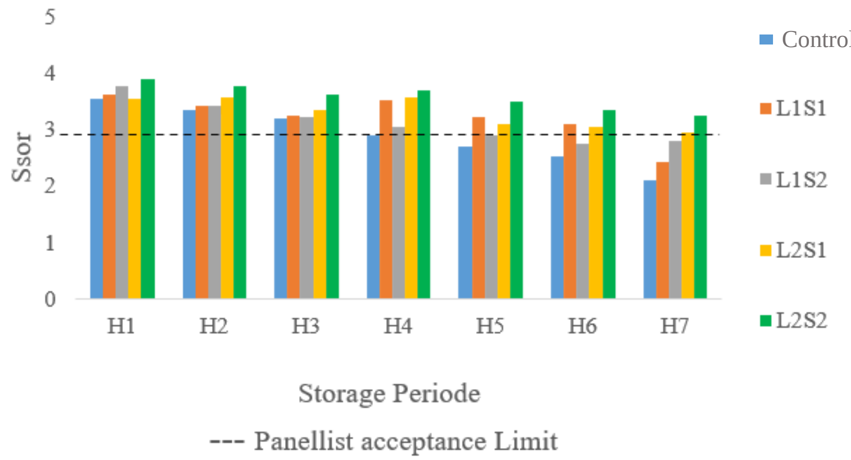

Figure 8. Changes in panelist's scores on the aroma of chrysanthemum flowers during storage

Figure 8 showed that flowers treated with L2S2 were still accepted by panelists until the end of storage (day 7) with a score of 3.25 while control flowers are no longer accepted on day 4 of storage with a score below 3. This was in line with the observations of moisture content, weight loss, and color that treatment with the L2S2 formulation has good quality in maintaining quality and shelf life. The color and freshness of the control flowers and flowers treated with L2S2 were shown in Figure 9.

(a) (b)

Figure 9. Chrysanthemum condition during storage a: Control on the 4th day b: Treatment L2S2 on the 7th day

3.7 Total Plate Count Analysis (TPC)

The total number of microbes is one of the parameters that determine the quality of a food product. Total microbial testing using the total plate count (TPC) method. The results of the TPC testing on day 7 of storage was shown in Table 4. Flowers treated with L2S2 were able to maintain microbial growth

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so that at the end of storage, the TPC value was the lowest and still at the threshold of food safety according to the Indonesian National Standard (SNI), which was 104 cfu ml^{-1} for fresh unprocessed products. These results indicate that coating treatment and the addition of antimicrobials can inhibit the rate of microbial growth.

Table 4. TPC value of chrysanthemum flowers on day 7 of storage

Treatment	Analysis of Total Plate Count (cfu ml^{-1})
L2S2	6666,67±1527,53
L2S1	15333,33±1154,70
L1S2	7666,67±3214,55
L1S1	7333,33±2516,61
Control	27333,33±2081,67

4. Conclusion

A corn starch coating solution with a 2% concentration was selected as the best solution based on droplet diameter and density. Edible coating treatment has a positive effect on maintaining the quality of chrysanthemum flowers during their shelf life. The use of edible coatings with a combination of corn starch and red galangal extract has been proven to inhibit respiration rate, moisture content, weight loss, and color change, and maintain consumer interest in organoleptic tests. Coating with a combination of 2% corn starch and 2% red galangal extract solution was more effective solution for maintaining the quality and extending the shelf life of chrysanthemum flowers. The coating formulation L2S2 (2% corn starch concentration and 2% red galangal extract with two spraying applications) produced the best quality parameters. It was proven that the coating treatment formulation L2S2 was able to maintain the moisture content at 86.02%, weight loss of 19.00%, TPC value of 6666.67 cfu ml^{-1} and ^{o}hue value of 347.04^{o} on the 7th day of storage, with panelist acceptance at a score of 3.25 (from 0-5) based on freshness, color, and aroma. For comparison, panelist acceptance for the control was only up to day 2, as the freshness on day three was below 3.

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