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The use aloe vera edible coating and non-destructive infrared based methods on the quality of shallots (*Allium cepa* L.)

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Abstract. Shallot (*Allium cepa* L.) is highly perishable and requires proper postharvest handling to maintain quality. This study evaluated the use of edible aloe vera coatings to extend shelf life and explored Near-Infrared Spectroscopy (NIRS) as a rapid, non-destructive method for quality assessment. Treatments included aloe vera gel concentrations (control, 15%, 20%, and 25%) and storage durations of 1–4 weeks. Parameters observed were moisture content, organoleptic properties, and NIRS prediction. Moisture content did not differ significantly among treatments at weeks 1 and 4. At weeks 2 and 3, however, the 15% coating retained higher moisture (83.59% and 81.01%), significantly different from the 20% and 25% treatments but similar to the control. Organoleptic evaluation by six panelists indicated that 20% aloe vera coating was optimal, providing effective protection without excessive moisture, which reduced quality at 25%. NIRS scanning (1000–2500 nm) revealed distinct spectral patterns associated with chemical composition, confirming treatment-dependent variation in shallot quality. These findings demonstrate that aloe vera coatings can maintain shallot quality during storage and highlight the potential of NIRS as a fast, eco-friendly tool for sorting and grading.

1. Introduction

Shallot (*Allium cepa* L.) is a commodity with high economic value and continuous demand for household consumption and other purposes. Given their susceptibility to damage and difficulty in maintaining freshness, proper post-harvest handling is essential [1]. Storage is the most critical aspect of post-harvest management, and one effective method to extend shelf life is the application of edible coatings [2]. Edible coatings are thin layers applied to the surface of agricultural products to extend the shelf life of perishable commodities [3]. Aloe vera contains bioactive compounds such as carbohydrates and lipids that can play a role in coating tissues and pores in fruits and vegetables [4]. Edible coatings can be made from proteins, polysaccharides, lipids, or hydrocolloids, and can also replace the natural wax layer lost during post-harvest handling [5]. [6] states that aloe vera gel consists of polysaccharides that contain many potential components, so that aloe vera can be applied in edible coating techniques and is able to prevent post-harvest damage to fresh foods such as glucomannan.

The use of edible coatings and storage duration will ultimately affect the quality of the resulting product, especially the quality of shallots. One factor that affects the quality of shallots with the use of aloe vera edible coatings is moisture content and organoleptic testing. Moisture content is important because the water content in food is related to food quality and can be used as an initial screening for measuring food product quality. Food with low moisture content has a longer shelf life than food with high moisture content [7]. Meanwhile, organoleptic testing is a method for evaluating the physical and

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chemical properties of a material based on human perception through the five senses. Stimuli that can be sensed can be mechanical (pressure, pricking), physical (cold, heat, light, color), or chemical (smell, aroma, taste). Smell, aroma, and taste are categorized as chemical properties because they are related to the chemical processes of the material (food) due to oxidation or interaction of the material with the environment.

Near Infrared Spectroscopy (NIRS) is a spectroscopy method that uses near infrared light reflection from the electromagnetic spectrum ranging from 760 nm to 2500 nm [8]. NIRS technology is based on the principle of C-H, O-H, and N-H molecular vibrations. Concentrations such as water, protein, fat, and carbohydrates can in principle be determined using classical absorption spectroscopy. One of its advantages is that NIRS can usually penetrate deeper into samples than visible infrared radiation. Therefore, near-infrared spectroscopy is very useful in investigating bulk materials with little or no sample preparation [9]. Several studies on the application of NIRS technology as an environmentally friendly post-harvest technology for sorting and grading food and agricultural materials have been conducted using fruits, coffee, rice, and herbs. Several industries use the NIRS method to predict the protein, fat, and carbohydrate content in agricultural products, as well as to analyze the level of ripeness and damage in fruits. NIRS technology plays a key role as an environmentally friendly post-harvest technology in the identification and evaluation of agricultural material quality. The main advantages of this technology include [10]: It is non-destructive to the material being measured, it does not produce waste, because this spectroscopy method measures samples directly and does not damage the quality of the samples being measured, it does not require other chemicals to assist in measuring samples, Fast and real-time measurement, because NIR spectroscopy can analyze samples and predict the quality of agricultural materials in seconds, Easy and accurate analysis, because this technology does not require complicated sample preparation, thereby increasing measurement accuracy and capability, and The quality parameters to be tested can be predicted simultaneously.

Research objectives: In general, the objectives to be achieved in this study are the use of edible coatings to extend the shelf life of shallots so that quality is maintained and the development of NIRS technology as an environmentally friendly post-harvest technology that is fast, real-time, and non-destructive for sorting and grading the quality of shallots.

2. Materials and methods

2.1 Shallot samples

The shallot samples used were harvested in May 2025 from the same garden. Drying will be carried out using a mechanical dryer until the shallots are dry and suitable for storage. The shallots are sorted and then packed in tightly sealed plastic bags and stored in a refrigerator at a temperature 7°C before being taken to the laboratory at USK for moisture content testing, organoleptic testing, and spectrum acquisition. Shallots that do not use aloe vera edible coating and shallots that use aloe vera edible coating are shown in figure 1, 2,3,4,5, and 6.



Figure 1. Shallot bulbs of Tajuk variety do not use aloe vera *edible coating*



Figure 2. Shallot bulbs of Tajuk variety use aloe vera *edible coating*



Figure 3. Shallot bulbs of Bima Brebes variety do not use aloe vera *edible coating*



Figure 4. Shallot bulbs of Tajuk variety use aloe vera *edible coating*



Figure 5. Shallot bulbs of Gayo variety do not use aloe vera *edible coating*



Figure 6. Shallot bulbs of Tajuk variety use aloe vera *edible coating*

2.2 Research design

This study used a completely randomized design (CRD) with a 4 x 4 factorial pattern, resulting in 16 treatment combinations with 3 replicates and 48 experimental units. Each experimental unit consisted of 10 samples of shallots. The factors studied were the use of aloe vera edible coating and storage duration on shallot quality.

The aloe vera gel concentration factor (K) consisted of 4 levels, namely: K0: Control, K1: 15%, K2: 20%, K3: 25%, and the storage duration factor (L) consisted of 4 levels, namely: L1: 1 week, L2: 2 weeks, L3: 3 weeks, L4: 4 weeks.

The data obtained was then analyzed using analysis of variance (ANOVA).

The mathematical model used in this experimental design was:

$$Yijk = \mu + Kj + Lk + (KL)jk + \varepsilon ijk$$

Where:

Yijk : Observation values for aloe vera gel concentration treatment at level j, storage duration factor at level k, and repetition i.

μ : Average value

Kj : The effect of edible coating aloe vera on shallots at levels j (K:1,2,3,4)

Lk : Effect of storage duration on shallot grade k (L:1.2,3,4)

(KL)jk : Observed values of the interaction between the concentration of aloe vera gel at level j and the storage time of shallots at level k

εijk : Experimental error for the aloe vera gel concentration factor at level j, shallot storage duration factor at level k, in repetition i

The research data were analyzed using ANOVA. If the F test results showed a significant effect (α = 5%), then the test of differences between treatment means was continued using a follow-up test procedure, namely the Least Significant Difference test at the 5% level (LSD 0.05).

2.3. Research procedures

2.3.1. Making adible aloe vera coating

The production of edible aloe vera coating was adjusted according to the treatment, namely 0% (Control) 15% (K1), 20% (K2), 25% (K3). For the control treatment, 100 ml of distilled water was used without aloe vera gel. For treatment K1, the concentration was prepared by mixing 15 ml of aloe vera extract and then dissolving it in 85 ml of distilled water. For K2, the concentration was prepared by mixing 20 ml of aloe vera extract and then dissolving it in 80 ml of distilled water. Next, for K3, the concentration was prepared by mixing 25 ml of aloe vera extract and then dissolving it in 75 ml of distilled water.

2.3.2. Storage of shallots

After drying, the shallots were stored at a refrigerator temperature of 7°C. Observations were then made on the water content and organoleptic tests were conducted on the shallots. Observations were made periodically at 1 week, 2 weeks, 3 weeks, and 4 weeks after treatment.

2.3.3. Acquisition of infrared spectrum in shallots

The infrared spectrum in the wavelength range of 1000–2500 nm with an interval of 0.02 nm for onion samples will be acquired using a portable NIRS instrument (PSD NIRS i16). To obtain optimal spectrum data, optical attenuation will be amplified to 4x and the number of scans will be set to 32 scans per sample [11]. Spectrum data in diffuse reflectance patterns will be stored in *.csv files for further processing and analysis. For validation, the quality of shallots will also be measured using standard laboratory methods. The process of acquiring infrared spectrum data for shallot samples is illustrated in figure 7.



Figure 7. Process of acquiring infrared spectrum data for shallot samples

2.4. Observation Parameters

2.4.1. Moisture content

The method of determining moisture content that is widely used for food products is the drying method or oven method. In this method, the onion sample is crushed in a porcelain dish, then weighed at 10 g using an analytical balance, and then placed in an aluminum dish. The sample and dish are dried in an oven for 3 hours at 105°C and cooled in a desiccator for 15 minutes. The sample is then weighed using an analytical balance. Moisture content observations are carried out periodically at 1 week, 2 weeks, 3 weeks, and 4 weeks after treatment.

2.4.2. Organoleptic testing

The organoleptic test used was a hedonic test to determine the level of consumer acceptance of shallots that had been treated during storage.

2.4.3. NIRS spectrum data analysis

Spectrum acquisition was performed in the wavelength range of 1000-2500 nm with an interval of 0.02 nm. Waves in this range were used because wavelengths below 1000 nm tend to be damaged, unstable,

and unable to provide the required information [12] states that the influence of chemical composition will result in the formation of peaks and valleys found in NIRS spectra.

3. Results and discussion

3.1. Moisture content

The effect of prolonged storage of shallots was not significant at 1, 2, 3, and 4 weeks after treatment. The average moisture content of shallots observed as a result of the use of aloe vera edible coating and prolonged storage can be seen in table 1.

Table 1. Average water content of shallots due to treatment with edible aloe vera coating and storage duration

Edible coating aloe vera (%)	Moisture content (%)			
	1 week	2 weeks	3 weeks	4 weeks
K0 (0%)	83.66	82.69 b	79.01 bc	77.33
K1 (15%)	86.48	83.59 b	81.01 c	78.62
K2 (20%)	84.12	76.55 a	75.91 ab	75.45
K3(25%)	84.59	77.30 a	75.12 a	74.77
LSD 0.05	-	3,26	3,80	-
Storage period	1 week	2 weeks	3 weeks	4 weeks
L1	83.69	81.48	78.24	77.65
L2	85.13	79.07	77.28	75.24
L3	84.11	79.52	76.98	76.08
L4	85.93	80.05	78.55	77.20

Note: Figures followed by the same letter in the same column are not significantly different at the 5% level (LSD 0.05 test).

Table 1 shows that the moisture content resulting from the application of aloe vera edible coating did not show any significant difference at 1 and 4 weeks after treatment. At 2 and 3 weeks after treatment, higher moisture content was found in the 15% aloe vera gel concentration treatment, namely 83.59% and 81.01%, which was significantly different from the 20% and 25% aloe vera concentrations, but not significantly different from the 0% concentration. The results showed that the storage period of shallots did not show a significant difference in moisture content at 1, 2, 3, and 4 weeks after treatment. [13] stated that moisture content is a crucial factor in determining the quality and shelf life of shallots. Therefore, managing moisture content with technologies such as edible coatings is important to inhibit water loss and maintain the texture and freshness of shallots. [14] states that in the first and last weeks, moisture content did not show any significant differences. This may be due to the relatively stable physiological mechanisms at the beginning and end of storage. At the beginning of storage, all samples had high internal moisture and had not yet experienced significant water loss. Meanwhile, at the end of the week, the water content tended to have reached a point of equilibrium due to a decrease in respiratory activity and uniform evaporation. In addition, the efficiency of aloe vera gel decreased over time due to layer degradation, which caused the treatment effects to no longer be significantly different.

The relatively high water content reflects the ability of the 15% layer to maintain the natural moisture of shallots without causing anaerobic conditions or excessive respiration inhibition, as occurs at higher concentrations. The 15% concentration forms a protective layer that is effective as a barrier to water vapor while still allowing essential gas exchange, so that the physiological processes of the bulbs are not disrupted. In addition, at a concentration of 15%, the viscosity and flow characteristics of aloe vera gel allow for more even distribution during application, resulting in a more stable and homogeneous layer that adheres better to the surface of the bulbs than higher concentrations, which tend to be thicker and more difficult to spread evenly [15]. [16] states that storage under controlled humidity conditions significantly reduces the rate of respiration and transpiration, thereby maintaining stable water content

in horticultural products such as onions. [17] states that onions are protected by a dry skin layer that acts as a natural barrier against water evaporation. This layer reduces direct transpiration from the inner tissue of the bulb to the environment, so that changes in moisture content during short storage periods tend to be insignificant.

3.2. Organoleptic Test

The use of edible aloe vera coating can slow down tissue softening by reducing the activity of pectinase and cellulase enzymes that break down cell walls. In addition, the polyphenols and antioxidants in the gel help stabilize cell membranes and prevent damage caused by free radicals. Aloe vera gel is effective in maintaining the physical quality and structure of tissue during cold storage [19]. Therefore, coating with the optimal concentration provides a physiological protective effect on the structure of onion tissue. The application of edible aloe vera coating in the first week of storage did not cause any significant changes in all organoleptic tests. In general, onion tissue is still relatively fresh and firm in the early weeks of storage. Physiological processes that accelerate softening, such as pectinase activity and water loss, have not yet been optimized. Organoleptic tests on the attributes of color, aroma, taste, texture, and overall acceptance with storage periods of 1, 2, 3, and 4 weeks for shallots are shown in figures 8,9,10, and 11.

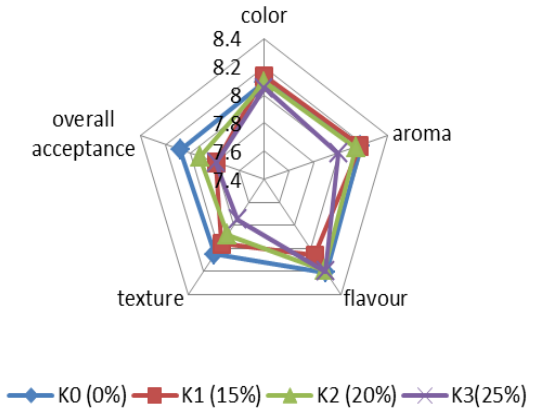


Figure 8. Organoleptic test using *edible coating* of *aloe vera* with 1 week storage of shallots

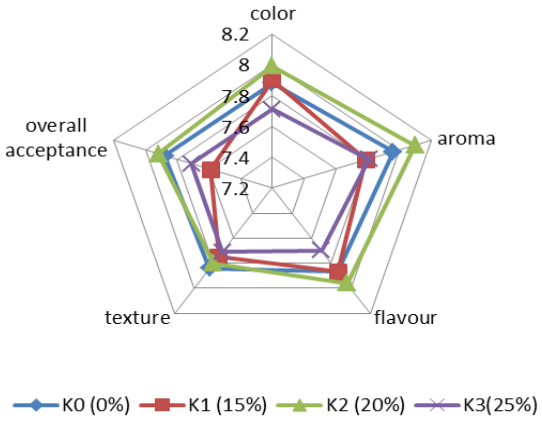


Figure 9. Organoleptic test using *edible coating* of aloe vera with 2 week storage of shallots

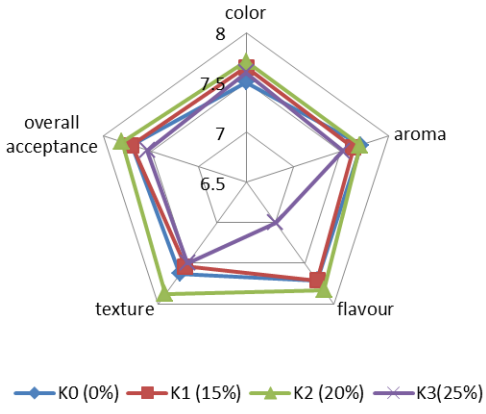


Figure 10. Organoleptic test using *edible coating* of aloe vera with 3 week storage of shallots

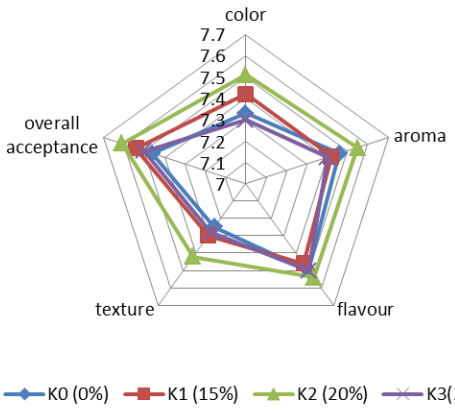


Figure 11. Organoleptic test using *edible coating* of aloe vera with 4 week storage of shallots

Based on figures 8, 9, 10 and 11 the panelists preferred the use of aloe vera edible coating at a concentration of 20%. This is because the use of 20% edible coating is the optimum condition where the aloe vera gel protects the shallots, whereas the use of 25% edible coating causes excessive moisture, which reduces the quality of the shallots. Additionally, during storage, metabolic processes such as respiration occur, producing heat and water vapor that accelerate softening and decay. Water loss causes a decrease in texture, while oxidative reactions reduce aroma and flavor quality, ultimately affecting the overall acceptance by the panelists. From a chemical–physical perspective, the optimal effect of the 20% aloe vera coating can be explained by its ability to balance moisture retention with adequate gas exchange. Although oven-dry measurements showed that the 15% treatment maintained higher total moisture at week 2 and 3 (83.59% and 81.01%), panelists preferred the 20% treatment. This discrepancy can be attributed to the distribution of water and surface micro-environment rather than total water content alone. At 20%, the coating provides sufficient protection against excessive water loss while still forming a film thin enough to allow proper O_2 and CO_2 diffusion. In contrast, the 25% concentration creates a thicker and more viscous film, which traps moisture at the surface, leading to localized anaerobic conditions, higher microbial activity, and textural softening. These effects negatively impact sensory attributes such as texture, aroma, and flavor, which were perceived unfavorably by panelists. Thus, while the 15% treatment preserved total water content, the 20% treatment offered a more favorable balance between water retention, gas exchange, and surface condition, resulting in better sensory quality.

3.3 NIRS spectrum data analysis

Portable NIRS spectrum data analysis of solution usage and soaking time was acquired in the wavelength range of 1000-2500 nm with an interval of 0.02 nm. A total of 18 samples with different processing variables were acquired. Wavelengths in the range of 1000-2500 nm were used because wavelengths below 1000 nm usually have unstable and tend to be damaged data, so the wavelength range of 1000-2500 nm was used to provide sufficient and necessary information. The initial spectrum of shallots can be seen in figure 12.

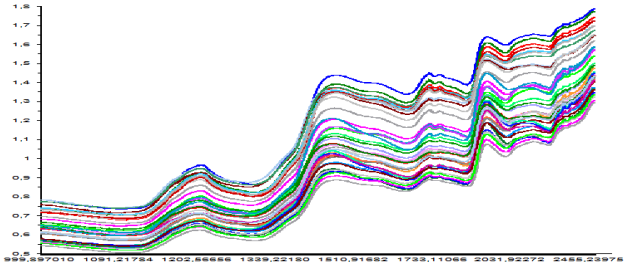


Figure 12. Raw Spectrum shallots

The shallot spectrum with a wavelength of 1000-2500 nm shown in figure 7 forms several peaks that contain the characteristics of samples containing chemical nutrients found in shallots. The scattered and non-overlapping analysis spectrum means that each sample has varying and diverse chemical contents depending on how it is treated.

4. Conclusions

The use of aloe vera edible coating at a concentration of 20% produced quite good results on the quality of shallots, and in organoleptic tests, panelists were more accepting of the use of edible coating at a concentration of 20% at all storage periods. With NIRS, the analysis spectrum obtained is spread out and does not overlap, meaning that each sample has a varied and diverse chemical content according to its treatment.

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