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Shallot extension shelf life with fogging and the storage temperature

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Abstract. Some leaves of plants can serve as an anti-pest and pathogen. Applications can be extracted or made of smoke. This method is generally done to preserve fish. The use in agriculture has not been generally used, so the specific purpose of this study is to use the smoke of some leaves and combine it with the storage temperature to extend the shelf life of shallot. The postharvest handling technology package of shallot will help farmers and entrepreneurs provide the shallot throughout the year and allow the government to stabilize the price. This research was conducted using a randomized block design arranged in a nested fashion. The first factor was the storage temperature (18°C, 22°C, and 26°C). The second factor was the plant leaves for fogging (*Mahogany*, *Tithonia diversifolia*, and cloves) and fungicides without treatment as positive and negative controls. The best fogging materials were *Mahogany* and *T. diversifolia* leaves, expressed in the weight loss percentage of 4.19% and 3.33%, respectively. The better storage of shallot was at a temperature of 22, where the weight loss of shallot was low (18.46%), the percentage of tuber roots and rottenness was 0%, the disease percentage was 2.75%, and tubers sprouted by 2.1 %.

1 Introduction

Shallot is a horticultural commodity in relatively high demand in the world. In 2021, the Top importers of Onions and shallots, fresh or chilled are the United States ($537,289.27K, 666,408,000 Kg), Germany ($210,710.18K, 251,350,000 Kg), Malaysia ($207,067.71K, 484,867,000 Kg), United Kingdom ($201,877.00K, 296,195,000 Kg), European Union ($200,393.88K, 298,148,000 Kg) [1]. Consumption of shallots in Indonesia has fluctuated and relatively increased. The average shallot consumption in 2020 reached 2,764 kg/capita/year [2]. To cover the shortfall, Indonesia imported shallot. Fluctuations shallot imports showed an increase in the number. As a result, Indonesia's shallot production in 2021 is 2,615,677; in 2050, it will be 4,189,324. Nevertheless, in 2020, Indonesia imported shallots from Vietnam, Malaysia, and Thailand 8.17 thousand tonnes of production in 2020, of 1,815,445 [3].

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The shelf life of shallot is relatively short; according to Sebsebe *et al.* [4], it is only three months at a temperature of 7.4ºC. The quality of shallot bulbs is characterized by color, water content, hardness, and durability of shallot bulb freshness during storage. Shallots have a relatively short shelf life. This characteristic can hinder the provision of raw materials, especially fresh ones. This is because, generally, horticultural products are living structures still undergoing chemical and biochemical changes due to metabolic activity. In order to reach the next distribution point with long freshness, special treatment is required. One treatment is cutting the leaves, followed by storage, which is an alternative treatment to protect shallots from damage due to decay and facilitate further handling [5].

Postharvest damage often occurs in shallot warehouse storage, such as shoot growth, softening of the tubers, root growth and decay, and the emergence of a dark-colored mass due to fungus. This damage decreases the shelf life and quality of shallot. Therefore, it is necessary to address this issue with proper postharvest handling.

Fumigation technology is one method for preservation. This process occurs because of the phenol compound, acids, and other components of the antimicrobial, antioxidant, and disinfectant [6]. Shallots can be preserved for up to four weeks by soaking in liquid smoke from coconut shells for 2 hours. There was a weight loss of 4.6%, damage of 1.17%, and moisture content of 82.5%. Smokeless shallots also had a weight loss of 33%, damage of 9.17%, and humidity of 87.29%. Therefore, soaking shallots for 2 hours in liquid smoke helps to retain their physical and chemical properties without changing their sensory characteristics [7]. Meanwhile, according to [8], storage at low temperatures can inhibit the growth of microbial, enzymatic, and chemical reactions that slow down the process of decay and damage and make the material more durable. Therefore, there is a need to test the effectiveness of these technologies. The research will determine differences in Fumigation materials and storage temperature on the shallot quality to extend the shallot's shelf life.

2 Materials and Methods

This study was divided into two steps. The first step was fogging, and the second was storage in different temperatures. The first phase of research used a completely randomized design; the treatments were the type of fogging material consisting of control (no fogging), fogging with mahogany leaves, fogging with clove leaves, fogging with T. *diversifolia* leaves, spraying with fungicide 0.5 ml/l (as positive in control). The second research phase used a randomized block design arranged in nested. The treatment was different in temperature consisting of 18ºC, 22ºC, and 26°C (room temperature). All of the treatments were repeated three times.

a. Material Preparation

Fresh shallots, including the Bima Brebes variety, were obtained from shallot farmers and used in this study. They were harvested 55 days after planting. The next step was the curing process conducted in the Greenhouse (GH). To determine the environmental conditions, the temperature and humidity of the GH were measured three times a day: in the morning, at 07.00 am, 12.00 pm, and 5.00 pm. This phase was carried out for ten days.

b. Fogging

Fogging materials were mahogany leaves with a water content of 75.1%, *T. diversifolia* leaves of 73.2%, and clove leaves with a water content of 77.6%. Each material consists of 10 kg of leaves. As a positive control, fungicide difenoconazole was used at the recommended dosage (0.5 ml/l), and the negative control was no fogging and pesticide. Fogging treatment of shallots was done for 8 hours, from 2.30 to 9.30 pm.

c. Storage

Smoked shallots were stored under temperature treatments 18, 22, and at room temperature (± 26°C) for ten weeks.

d. Observations

1) Weight loss (%): this observation was done by weighing the initial weight of smoked shallots minus the weight of the end of the observation by the formula: ((a-b)/a) x 100 %
2) Whereas *a* = initial weight of smoked shallots, b= weight of the end of the observation
3) The percentage of porous and dried shallots (%)
4) Calculate the percentage of the number of porous/dried tubers (%) after storage by the formula: ((a-b)/a) x 100 %, Whereas *a* = some shallots tuber, b = some porous /dried shallots.
5) Disease incidence (%). Calculate the percentage of the number of tubers attacked disease by the formula: ((a-b)/a) x 100 %, Whereas *a* = some shallot tubers, *b* = some tubers attacked disease.
6) The percentage of rooted shallot tubers (%), Calculating the percentage of rotten shallot tubers after storage by using a formula: ((a-b)/a) x 100 %, Whereas, *a* = a number of shallot tubers, *b* = a number of rotten shallot tubers
7) Sprouted shallot bulbs percentage (%), Calculating the percentage of sprouted shallot tubers after storage by using a formula ((a-b)/a) x 100 %, Whereas *a* = a number of shallot tubers, *b* = a number of sprouted shallot tubers.
8) Analysis of data: The collected data were statistically analyzed for variance analysis (ANOVA) to verify the level of significance. Duncan's Multiple Range Test (DMRT) was done to compare the effects of the treatments.

3 Result and Discussion

3.1. Percentage of Weight Losses After Fogging

Shallot weight loss when smoked with the leaves of T. diversifolia was 3.33%, whereas that smoked with mahogany leaves or clove leaves was 4.19 and 4.62%, respectively (Table 1).

Table 1. Percentage of weight loss after fogging.

Treatments	**Wight loss of shallot tubers (%)**
Fogging with Mahogany leaves	4,19 b
Fogging with Clove leaves	4,62 b
Fogging with *T. diversifolia* leaves	3,33 ab

The number accompanied by the same letters was not significant at 5% of Duncan's

3.2. Average of Weight Loss (%), Rooted Bulbs (%), Sprouted bulbs (%), Porous bulbs (%), and Disease attack (%) at ten weeks after storage

The highest weight loss was observed when fogging with clove leaves and stored at a temperature of 18ºC. However, statistically, it was not significantly different from the treatment without fogging, clove leaves, and *T. diversifolia* leaves stored at a temperature of 22ºC. The lowest weight loss was observed when *T. diversifolia* leaves were treated and stored at a temperature of 26°C.

Table 2. Average weight Loss (%), Rotted Bulbs (%), Sprouted bulbs (%), Porous bulbs (%), and Disease attack (%).

Storage Temperature	Treatments	Average of weights Lost (%)	Rooten Bulbs (%)	Sprouted bulbs (%)	Porous bulbs (%)	Disease attack (%)
18 ºC	No Fogiing	27.62 de	2.22 d	22.40 e	0.00 a	0.00 a
18 ºC	Mahogany	24.02 bcde	0.54 b	11.96 c	0.00 a	0.00 a
18 ºC	Clove	28.69 e	0.52 b	11.96 c	0.00 a	4.09 bc
18 ºC	*T. diversifolia*	22.34 abcd	1.17 ab	22.49 e	0.00 a	1.63 a
18 ºC	Fungicide	22.14 abcd	2.19 d	14.94 c	0.00 a	0.00 a
22 ºC	No Fogiing	23.57 ab	0.00 a	1.35 b	1.11 b	3.32 b
22 ºC	Mahogany	18.46 ab	0.00 a	2.03 ab	0.00 a	2.75 b
22 ºC	Clove	27.52 de	0.00 a	0.85 a	0.00 a	3.97 bc
22 ºC	*T. diversifolia*	27.29 cde	0.00 a	0.67 a	0.00 a	9.06 d
22 ºC	Fungicide	21.9 abcd	0.00 a	0.76 a	1.76 b	5.86 c
26ºC	No Fogiing	19.76 ab	0.00 a	0.00 a	1.12 b	3.54 b
26ºC	Mahogany	21.1 abcd	0.00 a	0.00 a	0.56 a	1.74 a
26ºC	Clove	21.12 abcd	0.00 a	1.20 a	3.91 d	10.58 e
26ºC	*T. diversifolia*	16.35 a	0.00 a	1.20 a	3.62 c	4.14 bc
26ºC	Fungicide	20.95 abc	0.00 a	0.00 a	0.42 a	4.89 c

The number accompanied by the same letters was not significant at 5% of Duncan's

In all fogging treatments, storage at 18ºC resulted in a higher percentage of tubers rooted than storage at 22ºC and 26ºC, but at the storage temperatures of 22ºC and 26ºC, the lowest percentage of the number of sprouted bulbs reached 0%.

The highest percentage of porous tubers was 3.91% in the fogging treatment with clove leaves and stored at room temperature (± 26 °C). In contrast, the lowest percentage of porous tubers reached 0% in the storage temperatures of 18ºC and 22ºC in all treatments, except the treatment without fogging.

In the treatment of storage temperature at 18ºC, without fogging, mahogany leaves and fungicide were the best treatments for percentage disease attacks, with the lowest reaching 0%. The percentage of disease was the highest in the treatment of storage at room temperature (± 26°C) with clove leaves fogging, reaching 20.58%, and the lowest was smoked with mahogany leaves by 1.74%.

Total Soluble solid and Hardness of shallot Bulbs

All treatments of the storage temperature and fogging led to an increase in total soluble solids and otherwise caused a decrease in the hardness of shallot bulbs (Figures 1 and 2).

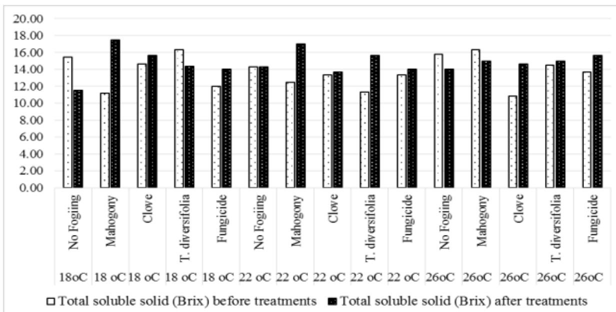

Fig. 1. The Total Soluble Solid of shallot before and after treatment with plant leaves and storage at different temperatures.

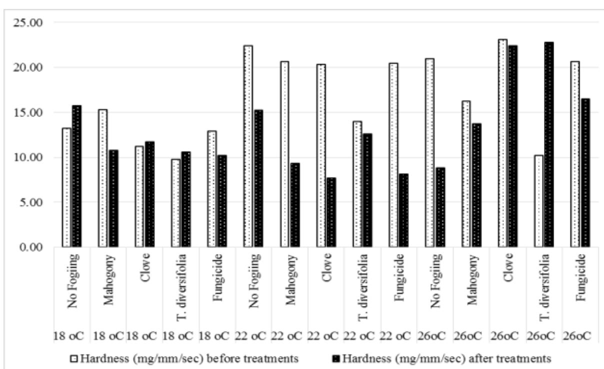

Fig. 2. The Hardness of shallot before and after treatment with plant leaves and storage at different temperatures

4 Discussion

Fogging with mahogany and *T. diversifolia* leaves treatments was the best because those did not lead to a high percentage of weight loss of shallot before storage. Tithonia (*Tithonia diversifolia*) is a wild species commonly found in medium to high altitudes. Its leaves contain flavonoid compounds, alkaloids, and tannins that can act as botanical fungicides, insecticides, antifeedants, and anti-oviposition agents [9]. Fogging could significantly reduce the water content. The depreciation weight of shallot occurred due to the process of evaporation (transpiration) during curing, causing water levels in tubers to be reduced, resulting in shrinkage of tuber weight. Fogging with clove leaves caused a high percentage of weight loss, which was 4.62%. This happens because the clove produced more smoke; it affected the evaporation of water from the smoked material, which would increase as a result of the increased thickness of the smoke around the bulbs, so weight loss was also increased. Clove leaf thickness of smoke could be seen from the higher water content compared to other leaf material, which was 77.6%. At a temperature of 18ºC, a better treatment contained in the leaves of *T. diversifolia* fogging and spraying fungicide. The best treatment was in *T. diversifolia* fogging, which had a relatively low weight loss of 22.34%, and the percentage of porous tubers was 0%. However, there was a percentage of disease at 1.63%, a percentage of tuber roots of 1.17%, and tubers emerged shoots at 22.49%.

Two compounds identified as plant volatiles, hexanal and 2-trans-hexenal, were placed on their ability to inhibit postharvest pathogens and their use in an overall postharvest strategy in combination with 1- methylcyclopropene (1-MCP) [10]. Fumigant toxicity tests conducted with essential oils of plants (mainly belonging to *Apiaceae*, *Lamiaceae*, *Lauraceae, and Myrtaceae*) and their components (cyanohydrins, monoterpenoids, sulfur compounds, thiocyanates, and others) have largely focused on beetle pests such as *Tribolium castaneum, Rhyzopertha dominica, Sitophilus* [11].

[12] The possibility of rejection is caused by the aroma of the leaf extract of *T. diversifolia*, which makes the larvae not want to eat. The treatment of fungicide indicated the lowest weight loss of 22.14%, the percentage of porous tubers by 0%, and 0% percentage disease attack, but there were rooted bulbs and tubers sprout at 2.19% and 14.94%, respectively; it caused a shallot apical meristem response for low-temperature storage (prechilling)

In the storage temperature treatment at 22ºC and ± 26ºC, leaf mahogany fogging and spraying fungicide treatment were the best treatments compared to other treatments; they were caused by low-temperature storage stimulating the growth of the apical meristem. The percentage of tuber sprout growth at 22ºC is lower than the percentage of tuber sprout at 18; it was caused by the response of the bulb inhibitors, which might be lost at lower temperatures, and the growth regulator appears later, which will affect germination. According to Salisbury and Ross [13], gibberellin may leak out of the storage container when it becomes much more permeable membranes at low temperatures. In some species, the hormone cytokinin or ethylene can act as gibberellins.

5 Conclusions and recommendation

Based on the results of this study, it was concluded that The fogging materials were better contained in mahogany and clove leaves, while the temperature for shallot storage was 22ºC and 26ºC. In contrast, 22ºC, the weight loss of shallot was 18.46%, the percentage of rooted and porous tubers was 0%, but the percentage of disease attacks was 2.75%, and tubers sprouted by 2.1%. Storage at room temperature (± 26 °C), the weight loss of shallot was 21.10%, the percentage of rooted and tubers sprouted 0%, but the percentage of porous tubers was 0.56%, and the percentage of disease attack was 1.78%. In the future v e, fogging materials could be used for the extended shelf life of Shallot bulbs.

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