Effect of citronella oil as a natural insecticide on post-harvest quality of cabbage

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Abstract. The post-harvest quality of cabbage is influenced by various factors, including storage conditions and pre-harvest treatments. Citronella essential oil has antibacterial and antifungal properties, making it a potential natural insecticide for horticultural crops This study aimed to evaluate the impact of citronella oil application in the field on the post-harvest characteristics of cabbage, particularly in minimizing weight loss, preventing decay, and preserving sensory quality. A Randomized Block Design (RBD) was implemented with four treatment groups: (A) citronella oil applied once a week (2 cc/L), (B) citronella oil applied twice a week (2 cc/L), (C) imidacloprid application (1 cc/L, the conventional farmer's method), and (D) a control group with no treatment. The results revealed that cabbage treated with citronella oil twice a week exhibited significantly lower weight loss and slower deterioration compared to other treatments. Sensory evaluation further confirmed that citronella oil application did not negatively impact consumer preferences for fresh and boiled cabbage. These findings underscore the potential of citronella oil as an environmentally friendly alternative to synthetic insecticides, contributing to the sustainable preservation of cabbage quality after harvest.

1 Introduction

Horticultural commodities, including cabbage, have a high water content, making them highly perishable. Improper handling during harvest, such as bruising or cutting, accelerates deterioration. In addition, the field and market environment exposes cabbage to pathogens that cause infection and reduce quality. Physiological processes such as transpiration and respiration also contribute to spoilage, although at a slower rate than microbial activity.

Pathogens from the soil persist on cabbage after harvest, entering through wounds caused by cutting or impact. Under favorable conditions, fungi, bacteria, and viruses become active, accelerating spoilage. Early spoilage is often characterized by the appearance of white or black fibrous mold, followed by tissue damage and a watery texture. Because cabbage is not

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washed after harvest, pathogen contamination cannot be easily removed, increasing the risk of post-harvest spoilage.

Lemongrass (*Cymbopogon citratus*) produces essential oil with antimicrobial properties due to its high citral content [1]. This oil has the potential to be used in edible coatings to preserve curly red chilies [2]. According to [3], natural insect and disease control in horticulture is environmentally friendly, easily biodegradable, leaves minimal residue, is safer for consumption, and increases the market value of organic products. This study investigated the impact of citronella oil as an insect and disease control method applied in the field on post-harvest cabbage quality.

2 Materials and methods

The study aimed to determine the effect of Citronella applied in the field on the quality of cabbage after harvest. The treatment of Citronella application was carried out in the field. The study of cabbage quality after harvest used a Randomized Block Design (RBD) with 4 treatments repeated 5 times. The treatments were A). Once a week for Citronella Oil 2 cc/l; B). Twice a week for Citronella Oil 2 cc/l; C). Once a week for imidacloprid 1cc/l (farmer's method); D). Control. Imidacloprid is a systemic insecticide included in the neonicotinoid group. The way imidacloprid works is by attacking the insect's nervous system, especially by interfering with the nicotinic acetylcholine receptor so that the insect is paralyzed and eventually dies. Observations in the laboratory consisted of observations of storage capacity consisting of weight loss, % of rot, and preference tests.

The cabbage samples used were clean, healthy and fresh cabbages. The cabbages were harvested in the morning, then cleaned first from damaged and dirty parts. The number of cabbage samples consisted of 6 pieces per treatment. Cabbage storage was carried out in a place with sufficient air circulation and light. The temperature and humidity recorded during the observation of storage capacity ranged from 26-28 degrees Celsius and 60-70%.

2.1 Weight loss

At the beginning of storage (week 0), each cabbage was weighed to determine the initial weight per cabbage. Furthermore, each cabbage was measured every week.

2.2 Rotten amount (%)

Every week, cabbage samples were observed and the number of rotten cabbages was calculated and compared with the number of cabbage samples. Observations of rotten cabbage were carried out for 3 weeks.

2.3 Cabbage sensory test

The sensors observed in cabbage were color, aroma, taste and texture. The cabbage samples tested consisted of fresh cabbage and boiled cabbage. The cabbage samples used for the sensory test were cabbage that was 3 days old after harvest. Fresh cabbage samples were in the form of cabbage leaves that had been washed and drained. Meanwhile, the boiled cabbage sample in the form of previously washed cabbage leaves was boiled using 1250 ml/20 cabbage leaves of boiling water for 1 minute, by changing the boiling water for each treatment. Then the cabbage was drained until the water drained and the temperature dropped. The assessment in the sensory test was in 2 stages, namely the sensory test with the aim of determining

whether the panelists could identify the residue of Citronella oil in the taste and aroma of fresh cabbage and boiled cabbage and the sensory test using the hedonic/liking method with a score range of 1 (very dislike) - 7 (very like).

3 Results and discussion

3.1 Weight loss

Weight Loss is a decrease in the weight of the material caused by evaporation or respiration of agricultural products. In addition, insect and disease attacks during storage can also cause a decrease in the weight of the material. In vegetables, weight loss is one indication of a decrease in quality. The weight loss trend in postharvest vegetables is closely related to the respiration and transpiration rates. Proper postharvest handling, including humidity and storage temperature, is essential to minimize weight loss and maintain the quality of vegetables to stay fresh until they reach consumers [4, 5].

Figure 1, in the control treatment, the cabbage had rotted in week 1, so that weight loss could not be observed in the following week. The results of the weight loss test during the 4-week storage period showed that the percentage of cabbage weight loss in the application of once a week for Citronella oil was lower than the other treatments. Cabbage treated with imidacloprid once a week experienced higher weight loss, possibly due to the interaction between the chemical insecticide and the storage environment, which accelerated evaporation. In addition, insecticide residues may have caused physiological stress, increasing respiration rates and further contributing to weight loss.

In horticultural products, weight loss has an impact on decreasing shelf life, appearance, and consumer acceptance [6,7]. The highest percentage of weight loss occurs in the first week of storage. This is because freshly harvested vegetables still have a high water content, and mechanical damage caused by wounds during harvesting can increase the rate of water evaporation and respiration. According to [8] weight loss during storage is mostly caused by transpiration and a small part by respiration which converts sugar into CO^2. The amount of weight loss that occurs is proportional to the transpiration and respiration processes.

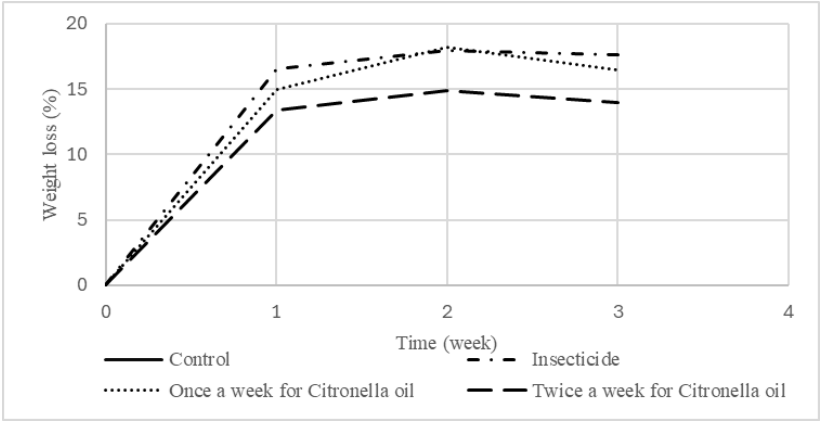

Fig. 1. Weight loss of cabbage during storage period.

3.2 Rotten amount (%)

The rot amount is intended to determine the rate of cabbage damage during the storage period. The rotting process occurs due to the presence of microorganisms such as fungi or bacteria,

environmental conditions that have high humidity and temperature, physical damage and internal factors, namely chemical processes and enzymes in plants. Rot in cabbage generally starts from the middle of the cabbage or cabbage stump.

In Fig. 2, the % of rot in the Citronella oil for twice a week treatment is lower than other treatments. Citronella oil twice a week treatment began to rot in the 3rd week of storage. Meanwhile, the control treatment rotted in the 1st week of storage and had the highest % of rot. This can be caused by Citronella oil applied to cabbage plants in the field diffused into the tissue so that it was able to withstand the development of fungi and bacteria.

According to [9], biocontrol agents have 4 main mechanisms, namely competition for nutrients and space, hyperparasitism, antibiosis and induction of resistance. As an antibiosis function, Citronella oil contains active compounds such as citral and geraniol which are antimicrobial. The compound inhibits the growth of bacteria and fungi by damaging the pathogen cell membrane or disrupting the microbial metabolism process, thereby reducing metabolic activity and causing microbial death. As an induction of resistance, the application of Citronella oil has the function of stimulating the formation of systemic resistance in plants by producing natural defense compounds such as the formation of peroxidase and polyphenol oxidase compounds that can fight pathogens.

Based on observations of the % amount of rot in storage for 3 weeks, it shows that the application of twice a week for Citronella oil can inhibit rot in cabbage until the 2nd week. This shows that the application of Citronella oil the field can minimize contaminant agents that cause rot in cabbage.

Vegetables and fruits have a high water content, this causes fruits and vegetables to rot more easily. Damage/rot in vegetables and fruits, apart from being caused by bacteria, fungi and post-harvest microorganism attacks, can also be caused by contaminant agents carried from the field. Infection generally occurs in parts of the fruit and vegetables that are injured, such as in knife cuts during harvest at the base of the cabbage. Infection is faster in a supportive environment. Citronella oil has been proven to have inhibitory effects on bacterial and fungal activity [10, 11]. Water solvents in Citronella oil applications facilitate the diffusion process through cell walls and membranes in plants. According to [12] antibacterials in essential oils are secondary metabolites of the phenolic and terpenoid groups. The antibacterial mechanism of phenolic and terpenoid compounds is to damage the structure of the cell wall, interfere with the work of active transport and the strength of protons in the bacterial cytoplasmic membrane.

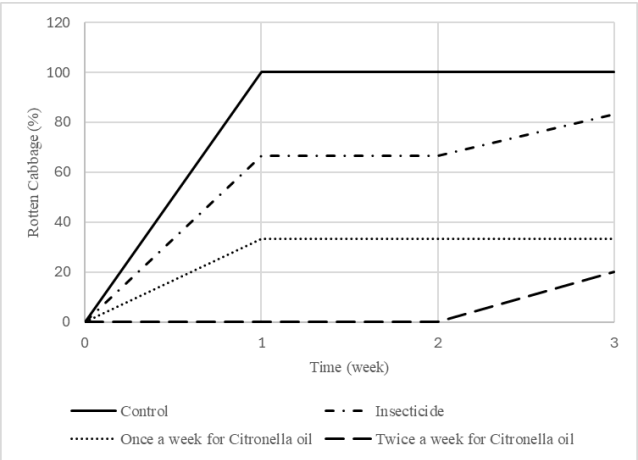

Fig. 2. Percentage of rotten cabbage during storage period

3.3 Sensory test

Citronella oil has a distinctive and strong aroma formed from volatile compounds such as citral, citronellol, and geraniol [13,14]. Citronella oil has the potential to interfere with the perception panel of the taste, aroma, or texture of cabbage. In Indonesia, cabbage is usually consumed fresh and boiled, to determine the effect of essential oil residues on the sensory quality of fresh cabbage and boiled cabbage, sensory tests were carried out on both.

Figure 3 presents the results of the identification test of the differences in taste and aroma detected by the panelists. The findings show that 40-50% of panelists detected differences in taste and 40-60% noticed variations in aroma between fresh cabbage and boiled cabbage in all treatments.

Differences in taste and aroma are possible because the essential oil compounds are partially absorbed into the cabbage tissue, thus slightly changing its natural taste and odor. During the boiling process, some volatile components of Citronella oil evaporate, which has the potential to reduce its impact on aroma and flavor profiles. Essential oils can interact with sulfur compounds that are naturally present in cabbage. These interactions can enhance or suppress certain flavors and aromas, making the processed cabbage slightly different from the unprocessed one.

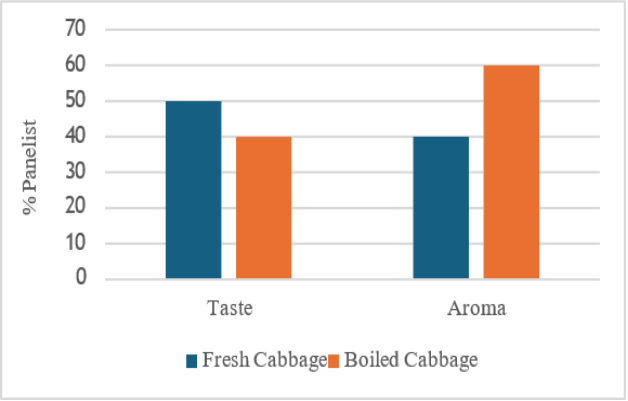

Fig. 3. Percentage of panelists who found differences in taste and aroma in fresh and boiled cabbage caused by treatment

Table 1. Hedonic Test of Organoleptic Properties of Fresh and boiled Cabbage

Parameter	P-value (α = 0,05)	
	Fresh Cabbage	Boiled Cabbage
Taste	0.975	0.846
Aroma	0.980	0.565
Color	0.237	0.589
Texture	0.859	0.880
Overall	0.771	0.981

Table 1, The hedonic test of the sensory properties of fresh cabbage and boiled cabbage, shows a significance value at p-value > 0.05 both in the sensory properties of taste, aroma, color, texture and overall preference. This shows that the panelists have a relatively similar level of preference for fresh cabbage and boiled cabbage that are treated with insecticides, Citronella oil once a week and twice a week Citronella oil. This shows that the application of

Citronella oil for natural insecticides does not cause any changes in panelist preferences for fresh cabbage or boiled cabbage. Although the panelists have previously tested the differences in taste and aroma between treatments in Figure 3.

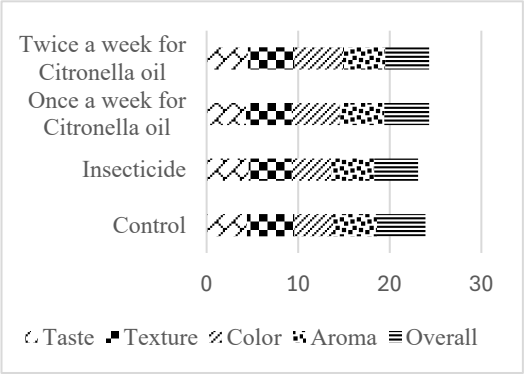

Fig. 4. Preference scores for fresh cabbage sensory

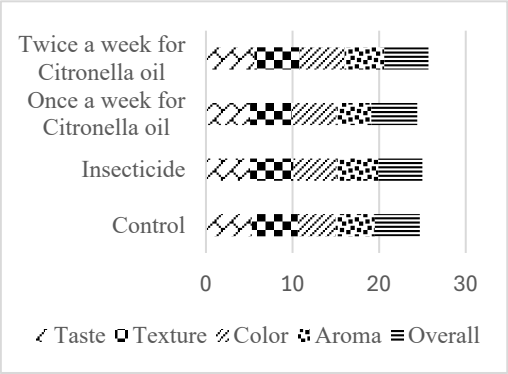

Fig. 5. Preference scores for boiled cabbage

Fig. 6. Fresh cabbage in 1st week of storage

4 Conclusion

This study demonstrates that the application of citronella oil as a natural insecticide on cabbage plants in the field can slow the rate of damage and reduce the percentage of weight loss during storage. The treatment of citronella oil applied twice a week yielded the best results in maintaining post-harvest cabbage quality. Additionally, sensory tests indicated that the application of citronella oil did not affect panelists' preferences for the taste, aroma, color, and texture of both fresh and boiled cabbage. This finding suggests that citronella oil can serve as an environmentally friendly insect control alternative without diminishing the organoleptic appeal of cabbage for consumers.

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