



## Effect Of The Number Of Packaging Perforations On The Quality Of Lettuce Vegetables (*Lactuca sativa L.*) at Room Temperature Storage

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### Abstract

**Background.** After harvesting and during storage, lettuce is prone to quality deterioration, so the post-harvest process must be considered to maintain its quality and shelf life.

**Aim.** This study aims to determine the effect of the number of perforations on packaging on the quality of lettuce (*Lactuca sativa L.*) during room-temperature storage.

**Methods.** This research was conducted in the Laboratory of the Faculty of Agriculture, Gunung Jati Independent University, Cirebon, West Java. This research was conducted in July 2024. This study used a Complete Random Design (RAL) with 5 (five) treatments repeated 5 times. The variables observed were weight loss, moisture content, damage rate, and vitamin C levels.

**Result.** The P3 treatment (4-hole perforation) is the best treatment for the quality of lettuce vegetables (*Lactuca sativa L.*) stored at room temperature.

**Conclusion.** Based on the research results, the number of perforations has a real influence on weight loss parameters, moisture content, and damage rate. However, it has no effect on vitamin C levels in lettuce vegetables.

**Implementation.** The best treatment was found at P3 (perforation 4), with the lowest percentage of weight loss, high moisture content, and the lowest level of damage at each observation.

**Keywords:** Packaging Perforation, Lettuce Quality, Room Temperature

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### INTRODUCTION

Lettuce (*Lactuca sativa L.*) is a vegetable with attractive leaf shapes, diverse colors, and unique textures. In addition to being unique and crunchy, lettuce has health benefits, containing a variety of vitamins A, B, C, calcium, phosphorus, iron, carbohydrates, fats, proteins, and energy (Novriani, 2014).

Lettuce vegetables have a crumbly texture after harvesting, making them easily perishable. The change is due to the rate of respiration, transpiration, and the cessation of nutrient supply, which will accelerate a number of *irreversible* reactions causing damage

to lettuce. According to Rosdiana (2021), the percentage of damage to fruits and vegetables after harvest reaches 25-28%, so damage can be avoided with proper post-harvest handling.

Packaging is a way of post-harvest handling that is expected to extend the shelf life and maintain the quality of lettuce. Plastic packaging prevents moisture from entering the lettuce, preventing moisture loss during storage. However, plastic packaging that is too tight also results in high humidity around the product (Anggraini & Permatasari, 2018).

Perforation holes, or they can also be called circulation holes, are used to prevent the accumulation of CO<sub>2</sub> gas or the shrinkage of O<sub>2</sub> gas in the packaging. Avoid the possibility of damage due to the accumulation of CO<sub>2</sub> and shrinkage of O<sub>2</sub> or the possibility of unwanted odors because in tight packaging, free oxygen will be used up in a short time, and respiration becomes anaerobic so that volatile substances such as alcohol and CO<sub>2</sub> are formed. Meanwhile, excessive perforation can reduce the water content in vegetables so that they change color (yellowing). If the stem is limp, then the decay cannot be stopped. (Anggraini & Permatasari, 2018).

According to the results of the study (Anggraini & Permatasari, 2018) In the number of perforations, four holes provide high moisture content results for mustard greens compared to those packaged without holes or 2 and 6 perforation holes. On packaging, plastic Low-Density *Polyethylene* (LDPE) mustard greens with four holes is the best treatment that can maintain the life of mustard greens until the 6th day of storage at room temperature. Research conducted (Maharani et al., 2021) on kale plants packaged with *Polypropylene Plastic* (PP), which is given a 4-hole and 8-hole packaging treatment, gives the best results on the color and texture of kale. According to research (Muliasari, 2022) that perforation hole 4 has a real effect on weight loss and vit. C and can maintain the shelf life of tomatoes up to 12 days of storage.

Plastic packers with the correct number of perforation holes can help regulate the circulation of water vapor, CO, and O<sub>2</sub> better and inhibit the occurrence of quality degradation. (Abdul Aziz, St, Sabahannur, 2023) Moreover, giving a large number of holes will dry the environment around vegetables and cause them to decrease in quality. Based on the explanation in the background, it is necessary to research the effect of the number of perforation holes on the quality of lettuce vegetables (*Lactuca sativa* L.) so that the proper treatment to maintain the quality of lettuce vegetables during the storage period can be known.

## LITERATURE

This mostly leafy vegetable has perishable properties, so the deterioration in quality can be seen easily. The process of respiration and ventilation is a factor that makes the harvested lettuce quickly wilt or decrease in quality. The freshness of lettuce leaves is seen from their sensory appearance, namely their texture, color, and aroma. The browning process of lettuce is characterized by leaf wilting, losing its green color due to chlorophyll degradation due to volatile compounds that appear (Desmi et al., 2023). Fresh lettuce tends to have a light green color, tends to dark green, has no physical defects, and is not diseased.

After harvesting, vegetables still undergo physiological processes even though they are not as complex as before harvesting, but if this is paid attention to properly, it will affect the deterioration of vegetables, both quality and shelf life. This deterioration is a limitation used to describe any changes that lead to loss of quality, physiological changes, mechanical damage, water loss, and all other forms of damage to the product. (Saidi et al., 2021).

Transpiration is a physical process in which water vapor escapes from plant tissues and evaporates into the surrounding environment, greatly affecting the level of humidity around the product. The diversity of the post-harvest respiration rate is often used as an indicator of the product's rate of deterioration. The higher the rate of respiration, the faster the rate of regression that occurs (Waryat, 2020). Packaging is one way to slow down the rate of transpiration and respiration for horticultural products such as fresh vegetables.

Plastic packers with the correct number of perforation holes can help better regulate the circulation of water vapor, CO<sub>2</sub>, and O<sub>2</sub> and inhibit the occurrence of quality degradation. Giving holes in plastic packaging aims to avoid or reduce the possibility of damage due to carbon dioxide accumulation and oxygen shrinkage or the possibility of unwanted odors because in tight packaging, free oxygen will be used up in a short time, and respiration becomes anaerobic so that volatile substances such as alcohol and carbon dioxide are formed (Anggraini & Permatasari, 2018). Packaging in perforated packaging (Perforation) on vegetables will inhibit shrinkage. To inhibit the rate of shrinkage, it is necessary to carry out packaging in plastic bags. However, the packaging must be perforated to prevent anaerobic reactions that cause unpleasant odors (*off odor*) (Devi, 2013).

## METHOD

This research was carried out at the Laboratory of the Faculty of Agriculture, Swadaya Gunung Jati University, campus I Jln. Pemuda, No. 32, Kesambi District, Cirebon City. This experiment will be carried out in July 2024.

The ingredients used in this study are lettuce vegetables (*Lactuca sativa* L.), a hybrid Batavia variety with uniform leaf height and width, and a number of 10 crop leaves obtained from Senun *Hydrofarm* in Sindangkempang village, Pancalang District, Kuningan Regency, Kuningan, West Java.

The tools used in this study are PP plastic with a thickness of 0.3 $\mu$  with a perforation hole of 6mm, a brown folder measuring 21.5x30cm, paper punchers, stationery, ovens, digital scales, *digital temperatures*, measuring flasks, Erlenmeyer glasses, scissors, mortar and pestle, plastic gloves, and tissues.

The research was conducted using a Complete Random Design (RAL). For the treatment, the Perforation Factor (P), which consists of 5 treatment levels, namely: P1 = the number of perforations of 0 holes (without perforation), P2 = the number of perforations of 2 holes, P3 = the number of perforations of 4 holes, P4 = the number of perforations of 6 holes, P5 = the number of perforations of 8 holes. Each treatment was repeated 5 (five) times, so there were 25 experimental units in total. Each experimental unit consisted of 8 lettuce vegetables, so the number of lettuce used was 200 stalks.

The variables observed in this study were weight loss, moisture content, damage level, and vitamin C. Data analysis was carried out with the F test and further tested with the Duncan Multiple Range Test (DMRT) at 5%.

## Implementation

The implementation of the research began by sorting the newly harvested lettuce. The lettuce vegetables used are healthy, disease-free, and uniform in weight. Then, the lettuce is packaged according to the treatment. Next, lettuce is stored at room temperature (20°C) in a laboratory room. Observations were made on the 2nd and 4th days after packaging.



Figure 1. Lettuce Vegetables (*Lactuca sativa* L.) Batavia varieties

### Weight Loss

The decrease in the weight of lettuce vegetables was observed before and after storage. Because lettuce vegetables that have high mechanical damage will also experience high weight loss. Weight loss observation was carried out on days 2 and 4. Here is the formula for the weight loss calculation.

$$PB = \frac{(w_0 - w_n)}{w_0} \times 100\% \dots$$

Remarks: PB = weight loss

W<sub>0</sub> = initial weight of lettuce vegetables

W<sub>n</sub> = final weight of lettuce vegetables

### Moisture Content

Each plant has a high moisture content, so to find out the moisture content in the plant by weighing the wet weight, the plant is baked for 24 hours at a temperature of 104°C, and then what remains is the dry weight of the plant without water. How to calculate it by weighing the weight of lettuce minus the dry weight of lettuce. Observations were made on days 2 and 4.

### Damage Rate

Post-harvest handling is crucial because it determines the effectiveness of the handling method used. The percentage of damage to a commodity can decrease and increase depending on the handling carried out. If the percentage of commodity damage is more than 20%, it will be considered high risk and damage will be experienced in the analysis sampling. The percentage damage rate of 20% will be used as a threshold point in determining the best

shelf life of Lettuce (Sitohang, 2016). The level of damage is calculated based on the weight of the damaged part of the lettuce compared to the total weight. Measurements were taken on days 2 and 4. Calculate the damage percentage using the equation:

$$\% \text{ damage} = \frac{\text{damage weight (g)}}{\text{total weight (g)}} \times 100\%$$

**Vit content. C**

This observation was carried out on the first and fourth (fourth) days by weighing 1 gram of sample material and crushing it with mortar until slurry was obtained. The porridge is weighed as much as 15 grams, put into a 100 ml measuring flask, and then equated to the limit mark. Then, the filtrate is homogenized and filtered with filter paper. The resulting filtrate is taken 25 ml and put into 100 ml of Erlenmeyer, then 1 ml of 1% amylum is added to it. The filtrate added with amylum is titrated with a standard iodine solution of 0.01 N until the color changes (Pertiwi, 2014). Vitamin C levels are calculated by the formula:

$$\text{Vitamine C (\%)} = \frac{\text{ml iodium} \times 0,01 \text{ N} \times \frac{100}{25} \times 88 \times 100}{\text{weight of material (mg)}}$$

**DISCUSSION**

**Weight Loss**

The results of the variegated fingerprint analysis showed that the number of perforations had a real effect on the weight loss of lettuce.

**Table 1 Average Weight Loss Percentage of Lettuce (*Lactuca sativa L.*) (%)**

NO	Treatment	Average Weight Loss Percentage	
		2 HSP	4 HSP
1	P1 (No Perforation)	28,9 e	62, 7 e
2	P2 (Number of Perforations 2)	12.6 c	52.1 c
3	P3 (Number of Perforations 4)	3,2 A	38.4 A
4	P4 (Total Perforations 6)	7,9 b	46.4 b
5	P5 (Total Perforations 8)	18,9 d	54,9 d

Description: Numbers followed by the same letter in the same column do not differ significantly according to the 5% DMRT test.

Table 1 shows that packaging without perforation holes (P1) and the number of perforation holes 8 (P5) show a higher average weight loss percentage than other treatments. The highest weight loss value in the observation of 2 HSP and 4 HSP was in the P1 treatment (without perforation), which was 28.9% in the observation of 2 HSP and 62.7% in the observation of 4 HSP. Meanwhile, low weight loss was found in the P3 treatment, which was 3.2% in the observation of 2 HSPs and 34.8% in the observation of 4 HSPs. Thus, the P3 treatment (Perforation Number 4) is the best number of perforation holes in suppressing the rate of water evaporation both during the storage period of 2 HSP and 4 HSP. Based on this data, the more perforations, the higher the weight loss due to the transpiration process running without obstacles because the product is directly exposed to the surrounding environment. The decrease in the weight of this lettuce plant due to the process of transpiration and respiration causes a decrease in product quality due to reduced water, which impacts the shrinkage of product weight (Hayati et al., 2023).

Low respiration and transpiration rates will suppress the rate of water loss, which is closely related to product weight loss; weight shrinkage occurs due to water loss in vegetables resulting from the evaporation process and water loss during respiration (Sarastulian, 2022) But on the contrary, too few or no perforation holes in the packaging, it can also cause high weight loss, This is suspected because the heat energy generated from the respiration process is trapped or does not come out of the lettuce packaging so that the hot temperature due to the respiration process triggers transpiration again in the package.

Weight loss of leafy vegetables occurs due to increased water loss due to transpiration and accelerated softening. Another factor that reduces boobo shrinkage in leafy vegetables is oxygen availability in the packaging. The higher availability of oxygen compared to carbon dioxide in closed packaging (without perforation) accelerates the respiration process, which encourages the evaporation of water from vegetable products (Bioati et al., 2023). Therefore, the P1 treatment (without perforation) produced the highest weight loss value of lettuce, 18.9%.

Vegetables and other horticultural products, like lettuce, undergo metabolic processes long after harvest because they are living organisms. When picked, vegetables and fruits still contain a lot of water. Vegetables, in particular, will wilt due to respiration and heat loss. Vegetables can suffer up to 40% more damage due to their physiological characteristics that do not entirely stop post-harvest metabolism, especially respiration. The

appropriate amount of packaging perforation is part of the way to prevent or limit the respiration of leafy vegetables (Waryat & Handayani, 2020).

**Moisture Content**

The results of the analysis showed that there was a real effect between the treatment of the number of perforation holes on the quality of lettuce vegetables (*Lactuca sativa* L.) at room temperature storage to the average water content of lettuce at the second observation and 4 days after harvest (HSP). The results of the statistical analysis are listed in Table 2

**Table 2 Average Percentage of Water Content of Lettuce (*Lactuca sativa* L.) (%)**

It	Treatment	Average Percentage of Moisture Content	
		4 HSP	8 HSP
1	P1 (No Perforation)	126.27 A	67.68 A
2	P2 (Number of Perforations 2)	153.80 c	88.55 c
3	P3 (Number of Perforations 4)	173.08 e	103.21 e
4	P4 (Total Perforations 6)	162.80 d	92.90 d
5	P5 (Total Perforations 8)	144.98 b	84.22 b

Remarks: Numbers followed by the same letter in the same column do not differ significantly according to the 5% DMRT test

Based on Table 2, the P3 treatment (number of perforations 4) shows a higher moisture content than other treatments. By providing the amount of perforations 4, the freshness quality of lettuce can be maintained at room temperature storage.

Perforation holes are used to prevent the accumulation of O2 gas in the packaging, which can trigger the respiratory rate (Pan & Asanatayart R., 2018). This is in line with the research of Aggraini and Permatasari (2018), which states that mustard greens' resistance to a shelf life of 6 days using LDPE packaging with a total of 4 perforations can provide the best treatment at a temperature of 25°C / room.

**Damage Rate**

The characteristics of damage to lettuce vegetables begin with a change in area, starting from brownish spots on the leaves to a complete change in color to blackish brown, dry leaves, and a change in aroma to an unpleasant odor.

Based on the results of the various fingerprints in Table 3, it was found that the treatment of the number of perforations on the packaging (without holes or controls, Perforation 2; Perforation 4, Perforation 6, and Perforation 8) had a real influence on the level of damage to lettuce vegetables (*Lactuca sativa* L.) at room temperature storage.

**Table 1 Average percentage of lettuce damage rate (*Lactuca sativa* L.) %**

It	Treatment	Average Damage Rate Percentage	
		2 HSP	4 HSP
1	P1 (No Perforation)	20.19 d	73,88 d
2	P2 (Number of Perforations 2)	6.84 bc	67.69 c
3	P3 (Number of Perforations 4)	3.09 A	41.74 A
4	P4 (Total Perforations 6)	6,6 b	53.74 b
5	P5 (Total Perforations 8)	11.6 c	70.00 cd

Remarks: Numbers followed by the same letter in the same column do not differ significantly according to the 5% DMRT test

The best treatment was found in the P3 treatment (number of perforations 4) because it had the average percentage of the lowest damage rate compared to other treatments, which was 3.09% at the observation of 2 HSPs and 41.74% at the observation of 4 HSPs. Meanwhile, the P1 treatment (without perforations) and the P5 treatment (number of perforations 8), both in the observation of 2 HSPs and in the observation of 4 HSPs, showed a higher percentage value of the damage level compared to other treatments (P2, P3, and P4).

The highest percentage of lettuce damage in both 2 HSP and 4 HSP observations was found in P1 treatment (without perforated holes), with a value of 20.19% in the observation of 2 HSPs and 73.88% in the observation of 4 HSPs. This is suspected because the packaging does not have a good air circulation system, so there is the condensation of water vapor as a result of the respiration process, which then sticks or drips back on the lettuce vegetables, triggering the growth of microorganisms such as fungi that damage lettuce leaves. In lettuce vegetables that are affected by the fungus, it is characterized by the presence of brownish spots on the leaves to a complete change in the color of the leaves, blackish brown, and a change in aroma to an unpleasant odor (Waryat & Handayani, 2020).



Figure 2. Lettuce Vegetable Packaging (*Lactuca sativa* L.) No condensing perforation holes

According to Mehyar and Han (2010), the increase in carbon dioxide concentration accompanied by a decrease in oxygen in vegetable packaging that does not have perforation holes allows anaerobic respiration or fermentation due to very low oxygen conditions in the packaging (1-2%) so that it can encourage the growth of pathogenic bacteria such as *Clostridium botulinum*, *Pseudomonas* spp., *Aspergillus* and *Penicillium* spp., which can cause damage to vegetables.

Furthermore, the high level of fragility in the P5 treatment (number of perforations 8) with a value of 70.00% is suspected because the water evaporation rate from lettuce is quite high due to too many perforation holes (number of perforations 8). This causes lettuce to lose a lot of water, which affects freshness. The lettuce also experiences physical damage, which is characterized by the occurrence of a color change to darken on the side of lettuce leaves.



**Figure 3. Lettuce Vegetables (*Lactuca sativa* L.) Which loses its freshness**

The water relationship in harvested horticultural products is an important quality characteristic of fresh fruits and vegetables that must be maintained for various reasons during the post-harvest chain. The consequences of water loss are wilting, loss of firmness, crispness, and freshness, thus affecting the commercial value of the goods and potentially causing physical damage to the product (Afetsu, J. Y., Dapaah, P. K., & Kyere, C. G. 2021).

Water condensation (residual condensation) on plastic packaging and vegetable surfaces in post-harvest can damage the external appearance, such as skin color, surface structure, and texture, and encourage microbial growth. Microorganisms require high relative humidity conditions (>95% RH) near the product to accelerate their growth, which has the potential to damage vegetable products (Kader, 2013).

### Vitamin C content

Vitamin C, ascorbic acid, is commonly found in fruits and vegetables. In the storage process, vitamin C is easily soluble in water and easily damaged by oxidation, heat, and alkali. (Asmara dan Amungkasi, 2019).

**Table 4 Average Percentage of Vitamin C Levels of Lettuce (*Lactuca sativa* L.) %**

It	Treatment	Average Vitamin C Levels (mg/100 g)
		4 HSP
1	P1 (No Perforation)	61.6 mg A
2	P2 (Number of Perforations 2)	70.4 mg a
3	P3 (Number of Perforations 4)	70.4 mg a
4	P4 (Total Perforations 6)	61.6 mg A
5	P5 (Total Perforations 8)	61.6 mg A

Remarks: Numbers followed by the same letter in the same column do not differ significantly according to the 5% DMRT test

Based on the analysis of the fingerprints, the number of perforations on the packaging had no significant effect on the vitamin C content of lettuce at the shelf life of 4 HSPs. However, the P3 treatment (Total Perforations 4) and P2 treatment (Total Perforations 2) showed a high content value (70.4 mg/100 g) compared to the treatments P1 (No Perforation), P4 (Total Perforations 6) and P5 (Total Perforations 8). So that the lettuce can be packaged with 2 and 6 perforation holes to maintain its vitamin C content well during the fourth day of storage.

The difference in the decrease in vitamin C content is because vitamin C is unstable and easily oxidized if exposed to air (oxygen), and the process can be accelerated by heat. Vitamin C is easily oxidized because in its compound, there is a highly reactive hydroxy group (OH) (Masfufatun et al., 2010).

The oxidation process in the P4 (Number of Perforations 6) and P5 (Number of Perforations 8) treatments results in the loss of nutrients contained in fruit, lettuce, and vegetables, including vitamin C. Loss of vitamin C can also result from packaged vegetables not having good air circulation, as in the P1 (No Perforation) treatment. In tight packaging of fresh vegetables, the hot air produced from respiration destroys vitamin C. (Masfufatun et al., 2010).

## CONCLUSION

Based on the research results, it can be concluded that the number of perforations has a real influence on the parameters of weight loss, moisture content, and damage rate. However, it has no effect on vitamin C levels in lettuce vegetables. The best treatment was found at P3 (perforation 4), with the lowest percentage of weight loss, high moisture content, and the lowest level of damage at each observation.

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