Effects of Temperature on The Quality of Garlic (*Allium sativum* L) cv. Lumbu Kuning During Storage

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Abstract. The quality of garlic bulbs may be deteriorated under storage. This work aimed to study the effect of storage temperature on the quality of garlic during storage. A local garlic variety, i.e. Lumbu Kuning was used in the study. The bulbs were collected from a farmer. After drying, the bulbs were subjected to different temperature storage conditions, i.e. 0°C; 7°C (RH 50-70%, darkness), and a room temperature (29-31°C, RH 70-80%). The treated bulbs were stored for 6 months. The parameters observed were weight, numbers of empty and sprouted bulbs. The treatments were carried out in three replications (54-67 bulbs or 300 g per replicate). The results showed that the highest weight loss was found from the bulbs stored at 7°C (25.08%), followed those stored at the room temperature (18.76%) and 0°C (10.47%). The highest sprouting percentage occurred in those stored at 7°C (25.16%). The empty bulbs percentage was found for that garlic stored at 0°C and a room temperature were 6% and 13%, respectively. The study suggests that storage condition at 0°C is recommended for long-term storage of garlic bulbs.

1. Introduction
Garlic (*Allium sativum* L) known in Indonesia for seasoning and source of medicine. Annual garlic consumption for household and industrial needs reached 556,000 tons in 2017, but only 21,000 tons of it was planted domestically. The remaining 535,000 tons were imported from China and India [1]. The government set the program to realize the self-sufficiency of garlic in 2021. Garlic is a seasonal product, for marketing and consumption purpose, understanding a better storage method will be very important to keep garlic fresh.

Garlic is not considered to be a very perishable commodity [2], however, its quality commonly deteriorates under storage after 6 months harvested [5]. A well preserved of the dried neck and outer skin of the bulbs extend its shelf life, although eventually sprouted. This means the dormancy of the bulbs has ended, metabolism increases, and the quality changes [3]. Understanding the physiology of bulb dormancy is a necessity for developing a better storage system. Several studies on the effects of storage condition on the quality showed that garlic can be stored at room temperature (20-30°C) for 1 or 2 months [4]. However, the bulbs eventually lose their firmness and become spongy and discolored due to water loss. Dormancy ends quickly if the bulbs are stored at the temperatures between 5 and 18°C; the optimum storage temperature range from -1 to 0 °C.

Responses of garlic bulbs to the cold storage conditions are cultivar dependent. After 9 months of storage at -3°C, if garlic bulbs are placed at a room temperature, their qualities (firmness and taste) retained for at least 2 months. Garlic bulbs lost 4.38-5.57% of their weight when stored in a cold storage
(7.8-10.3°C RH 70%), while their losses were slightly bigger (4.44-5.77%) when stored at a room temperature[6]. A number of the sprouted blubs was higher (24.68-64.80%) when stored at a cold storage system than those at a room temperature (19.87-34.03%). However, the number of the empty bulbs was less (2.39-12.17%) when stored at the cold storage than at the room temperature [6]. Therefore, it is necessary to find a proper storage for garlic bulbs to maintain a high quality both for consumption and stock seeds. There are few studies on the effects of storage conditions to the garlic bulb qualities [7,8,9], however, proper storage condition for a local variety, such as Lumbu Kuning, is limited. The objective of this study was to examine the effect of storage temperature on the quality of garlic during storage.

2. Materials and Methods
Garlic bulbs cv. Lumbu Kuning, were harvested from a local farmer orchard. The bulbs were cured and dried until the water content was 60%. Three hundred grams of each dried garlic bulbs (54-67 cloves) were stored experiments were set at three different temperatures, i.e. 0°C; 7°C (RH 50-70%) and a room temperature (29-31°C, RH 70-80%). The bulbs stored in the cold storage (0 and 7ºC) were set under darkness condition (Figure 1). The treated bulbs were stored for 6 months. The parameters observed were weight, numbers of empty and sprouted bulbs. The treatments were carried out in three replications.

![Figure 1. Experimental condition. Sample of garlic bulbs (left), storage conditions at 0ºC (middle), and 7ºC (right)](image)

3. Results and Discussion
The bulb weight losses varied at different storage temperatures. The highest was that stored at 7ºC (25.08%), followed those stored at the room temperature (18.76%) and 0ºC (10.47%) (Figure 2). A highest empty bulbs were found from that stored at the room temperature (Figure 2 and Table 1). The results indicated that low-temperature storage (7°C; RH 50-70%) is a good storage system for garlic bulbs could reduce the loss of water content of garlic during long-term storage. The empty bulbs percentage was found for those garlics stored at 0ºC and room temperature. The room temperature storage condition resulted in higher empty bulbs than 0ºC (Figure 2 and Table 1).

The study also showed that the highest sprouting percentage was found for garlic bulbs stored at 7ºC (RH 50-70%), i.e. 25.16%. The high sprouting bulb is probably due to the dormancy period was rapidly broken during the storage temperatures of 5 to 10ºC [10], as the result of a non-activation of γ-glutamyl peptidase in garlic during storage at 4 ºC [11]. A number of the sprouting garlic bulbs were observed starting at 3 months after the storage at 7 ºC, whereas no bulb sprouting occurred from those stored at 0ºC and a room temperature. The bulb sprouting is associated with the increasing number of isoaflin during storage at low temperature as the result of the degradation of the γ-glutamyl peptides by an increased activity of a trans-peptidase stimulated following the breaking of dormancy [9]. Physically, the emergence of the sprouting is controlled mainly by external factors, such as a cool temperature (7ºC) [12].
Figure 2. Weight losses of garlic bulbs stored at different temperature for 6 months

Table 1. Empty and sprouting bulbs of garlic cv. Lumbu Kuning during 6 months storage at the different temperature

| Month | Empty bulb (%) | Sprouting bulb (%) |
|-------|----------------|--------------------|
|       | 0°C  | 7°C  | Room Temperature | 0°C  | 7°C  | Room Temperature |
| 1     | 0    | 0    | 0                | 0    | 0    | 0                 |
| 2     | 0    | 0    | 0                | 0    | 0    | 0                 |
| 3     | 0    | 0    | 0                | 0    | 4.67 | 0                 |
| 4     | 0    | 0    | 13               | 0    | 20.67| 0                 |
| 5     | 6    | 0    | 13               | 0    | 23.11| 0                 |
| 6     | 6    | 0    | 13               | 0    | 25.16| 0                 |

Figure 3 shows the conditions of garlic after being stored for 6 months for temperature conditions of 0, 7 °C and room temperature. This study suggests that a proper temperature condition is important to maintain garlic bulbs for seed stock.

Figure 3. Garlic bulb condition at 0°C (a), 7°C (b) and room temperature (c) for 6 months storage in dark condition

4. Conclusion
Temperature conditions during storage affected the quality of garlic bulbs cv. Lumbu Kuning. Storage at 0°C (RH 50-70%) in darkness resulted in the lowest percentage of weight and empty bulbs. Temperature storage of 7°C resulted in highest sprouting bulbs. The study suggests that storage condition at 0°C is recommended for long-term storage of garlic bulbs.
5. References

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