The potential of the ZECC–washing combination to extending the mango’s shelf life

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Abstract. A combination of Zero Energy Cool Chamber (ZECC) and postharvest technology is applied to avoid quality loss and maintain the firmness mangoes. The aim of the present study is to evaluate the combination of ZECC and washing to remove fungus treats on mangoes. The washing applies the water and detergent + Ca(OH)$_2$ (Calcium Hydroxide). The observed parameters are the visual appearance of fruit surface, color, sap, and dirt. The washing treatment of 1% detergent + 0.5% Ca(OH)$_2$ demonstrated the best mango performance by visualizing smoother surface, less discoloration, and clean from sap and dirt. These results provide the potential of the ZECC–washing combination to extending the mango’s shelf life.

1. Introduction

Cold storage is the one widely practiced method in postharvest treatment. However, the procedure, such as using a refrigerator, sometimes requires a high electricity demand. In rural areas, which generally are major agricultural producers, usually face problems on the electricity supply. Besides, high operational cost and non-environment friendly freons generation from cold storage systems are also the concerning issues for farmers performing postharvest [1,2]. The problems above assert the need to provide a low-energy, low-cost, and eco-friendly cold storage system. The potential existing storage system is Zero Energy Cool Chamber (ZECC) [3–5].

Zero Energy Cool Chamber (ZECC) is an eco-friendly and inexpensive postharvest technology to store fruits and vegetables since its application does not use electricity. In addition, this cold storage system only requires materials that are easily found, namely bricks, sand, plastic roofs, and water [3,6].

Research on fruits and vegetable storage using ZECC is gradually increasing in the last few years. Kamilia (2017) and Dirpan (2018) examined the quality of mangoes and tomatoes stored in ZECC but still found growing fungus [7]. The Combination of ZECC and fruit washing is considered as an alternative treatment to reduce growing fungus and extend the shelf life of mangoes. The ZECC is expected to provide a low-cost storage system to mango farmers that could improve the nutritional and economic conditions of their households.

2. Material and method

This experiment was conducted on June – July 2019 at the Food Processing Laboratory and the Chemical Analysis and Food Quality Supervision Laboratory of the Food Science and Technology Major, Agricultural Technology Department, Agriculture Faculty, Hasanuddin University, the Global Development Learning Networking room (GDLN) of the Research Activity Center (PKP), and...
Perumahan Dosen Unhas Tamanlarea, Makassar. The number of mangoes used in this study is shown in the table below:

| # mango | Storage | ZECC | Total |
|---------|---------|------|-------|
| Room    | 12      | 12   | 24    |

Fresh mangoes that were not rotting and injured were sorted and selected. The collected mangoes were then graded based on the maturity level. The Zero Energy Cool Chamber (ZECC) was prepared with chemical disinfection by spraying 0.5% chlorine + 70% alcohol as the most powerful one and wider spectrum activity to inhibit microorganism growth. The fruits were prepared and washed using water and detergent + Calcium Hydroxide by following the appointed treatments. The washed mangoes were then dried and stored in ZECC and at room temperature. Mangoes were observed for the appearance every day until the 8th day of storage. The treatments are:

- A0: Control (without washing)
- A1: Washing with water
- A2: Washing with detergent 1% + Ca(OH)₂ 0.25%
- A3: Washing with detergent 1% + Ca(OH)₂ 0.50%

At the end of the experiment, the mangoes were visually observed for physical parameters of the surface, color, sap, and dirt.

3. Results and Discussion
A preliminary study of the Zero Energy Cool Chamber (ZECC) demonstrates the better visual or physical quality physical compared to the one stored at room temperature. Mango stored in ZECC has a smoother surface, less skin discoloration until the 8th day of storage, a lack of lenticel spots, and no fungus on the surface. On the other hand, mango stored at room temperature has a rougher or wrinkle surface, slightly noticeable skin discoloration, lenticel spots appearance started from the 5th day of storage, and growing fungus in some samples. The results indicate the possibility of extending the shelf life of mango by using ZECC compared to the storage at room temperature.

3.1. Storage at Room Temperature

![Figure 1. Control (Mango without Washing) (RT: Room Temperature).](image_url)
Figure 2. Mango washed using water.

Figure 3. Mango washed using Detergent 1% + Ca(OH)$_2$ 0.25%.

Figure 4. Mango washed using detergent 1% + Ca(OH)$_2$ 0.5%.
3.2. Storage at ZECC temperatures

Figure 5. Control (Mango without Washing).

Figure 6. Mango washed using Water.

Figure 7. Mango washed using Detergent 1% + Ca (OH) 2 0.25%
3.3. Mango’s Surface

Visual observations on mango’s surface indicate the better performance of mango stored in ZECC than at room temperature. Mangoes stored in ZECC had smoother and not wrinkled surface until the 8th day compared to the one stored at room temperature. The better performance of mangoes stored in ZECC might be caused by the higher humidity (relative humidity, RH) of 80% to 98.04% compared to the room temperature of 50% to 56.90%. This is in accordance with Muchtadi (1992), stated that all types of mangoes are vulnerable to the cold condition, indicated by dark patches, uneven ripening, and failure to produce good taste and color [8]. Relative humidity between 85-90 % is necessary to avoid wilting and softening in various fruits and vegetables.

The temperature at the storage room is higher than in ZECC. The temperature in ZECC is 24-25°C, while the room temperature is 26-31°C. Storing mangoes at room temperature could facilitate a higher respiration rate compared to the one stored in ZECC. This situation could affect to make mango’s surface wrinkled.

Respiration is the primary metabolic process of harvested products. The process could affect the physical and chemical changes in mango. Respiration employs oxygen to burn more complex organic compounds into simpler molecules that produce energy. Respiration rate is possible to apply as a guide of the postharvest fruit’s shelf life since it is associated with the deterioration quality rate. Rizkia (2004) states that the lower the respiration rate, the more potential the fruit can be stored in fresh form, and vice versa [9].

3.4. Color of surface

The color change is a modest indicator to determine the maturity level of mango. The change could start from the top to the bottom of the fruit. The discoloration is affected by the pigment found in the fruit. Chlorophyll is one of the pigments found in mangoes. In mango, the green color could turn into yellow, red, or orange. This is in accordance with Mulyati (2012), who states that in immature fruits, chlorophyll content is greater than other pigments to visualize green color to fruits [10]. During the ripening, chlorophyll will degrade and turn to other pigments that cause fruits and vegetables to be yellow, orange, or red.

The overall treatments demonstrate no noticeable color changes of mangoes until the 6th day of observation. Mango starts to turn into yellowish since it is classified as climacteric fruits that increase its maturation during storage. The maturation occurs along with the breakdown and degradation of chlorophyll so that other color pigments such as yellow and red begin to appear. This is in accordance with El-Zeftawi et al. (1988), states that the level of chlorophyll content in fruits that are still green has decreased during the storage period so that other pigments will appear, which causes the fruit to be yellow or orange [11].
3.5. Sap and Dirt

Many factors can affect the quality of mangoes, which include the sap attached to the fruit surface. The mango sap is a thick liquid that comes out of the fruit stalk after being picked. Mangoes without immersion and washing (control) will remain the sap attached and cause the bad visualization of mango’s surface. Changes in the appearance began to appear on the 6th until the end of the experiment, show burns, and darkening of the surface of the mango base. The appearance might be caused by the sap compounds or fractions that can accelerate fruit rot. Negi et al. (2008) state that the sap contains two fractions, namely the oil fraction and the polysaccharide-protein fraction [12]. The fractions can enter through mango’s lenticels. The sticky sap skin attracts microorganisms (fungi and bacteria) to come and cause fruit spoilage, reducing the appearance and quality of fruit storage.

![Figure 9. Mango without Washing (Control).](image)
4. Conclusion
The best performance of mango is demonstrated by the combination of ZECC and washing with detergent 1% + Ca(OH)$_2$ 0.5% with a smoother skin surface, inconspicuous color change, and cleaner from sap and dirt. Therefore, washing mango can potentially extend the shelf life of mango.

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