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The Quality of Tomato (*Lycopersicum esculentum* Mill.) Stored on ZECC (Zero Energy Cool Chamber)

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Abstract. Post-harvest handling fruits and vegetables in Indonesia has not received enough attention. This can be seen from the post-harvest damage of 25-28%. ZECC (Zero Energy Cool Chamber) is one of the eco-friendly and low-cost post-harvest technologies that can be used to store fruit and vegetables. The aim of the study was, to know the quality of tomatoes stored in ZECC, cold temperature, and ambient temperature. Secondly, to determine time length storage of tomatoes using ZECC. Data processing used a quantitative descriptive method with three replicates. The chemical analysis result of tomato stored in ZECC was vitamin C content 39.95 mg / 100g, pH level 4.15, total acid 0.40, total soluble solids 5.4⁰Brix, weight loss 4.66 grams. The quality of tomatoes stored on ZECC is better than tomatoes stored in cold storage and ambient temperature. Tomatoes can be stored in ZECC for 20 days, cool temperature storage of 15 days, and storage of ambient temperature 10 days.

1. Introduction

Cold storage is one method used for post-harvest handling. However, the cold storage is constrained by the lack of electricity in rural areas which are generally agricultural centers [1], besides that, the high operational cost of cold storage is a significant obstacle for farmers to conduct postharvest handling using cold storage methods, therefore another method is developed, namely ZECC (Zero Energy Cool Chamber) [2–7], which is cheap (low cost), environmentally friendly, and does not require electricity (zero energy) [2].

Zero Energy Cool Chamber is one of the environmentally friendly and low-cost post-harvest technologies that can be applied to store fruit and vegetable after harvest. ZECC commonly called a fruit storage system and environmentally friendly vegetable because the application does not require electricity [7].

Study result of ZECC in Makassar South Sulawesi showed that ZECC was able to decrease the temperature as well as increase the relative humidity (RH) of condition inside ZECC [8]. The average temperature ZECC obtained was $\pm 26^{\circ}\text{C}$ while the outside or room temperature was $\pm 33^{\circ}\text{C}$. The RH can be increased from $\pm 72,9\%$ to $\pm 87,2\%$. Unfortunately, the ZECC application on fruit and vegetable is still unknown. Therefore the main objective of this research is to determine the tomato qualities in some post-harvest handling namely room temperature storage, cold storage, and storage using ZECC.



2. Research Methodology

2.1. Time and Place

This research was conducted on September 2017 - January 2018, in Food Processing Laboratory, Chemical Analysis and Food Quality Monitoring Laboratory, Study Program of Food Science and Technology, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, and Lecturer Housing of UNHAS Tamanlarea, Makassar.

2.2. Tools and Materials

Tools and materials used in this research consist of processing tools and physical and chemical analysis tools namely, fruit shelf, temperature and RH sensor, hose, balance, analytical balance, microscope digital, hand refractometer digital, refrigerator (temperature of $\pm 12^{\circ}\text{C}$, RH= $\pm 44\%$), oven, desiccator, porcelain cup, pH meter, stirrer, beaker, erlenmeyer, measuring glass, volume pipette, bulb, plate, spoon, knife, cloth, blender, drop pipette.

Materials used in this study were fruits, ripe tomato, demineralized water, NaOH, iodine, KI, PP (Phenolphthalein) indicator, alcohol, buffer solution pH 7, mineral water.

2.3. Study Procedure

Procedure tomato quality storage in ZECC :

1. The ripe tomato was obtained from tomato farming in Kanrepia, Malino.
2. Tomato washed and cleaned
3. Tomato was stored, as following treatments:
 - a. Ambient Temperature. Tomato were stored in outdoor using a plastic basket
 - b. Cold Temperature (temperature= $\pm 12^{\circ}\text{C}$, RH= 44%). The fruit was stored in a refrigerator
 - c. ZECC (temperature = $\pm 26^{\circ}\text{C}$, RH. $\pm 72,9\text{-}\pm 87,2\%$). Tomato were stored in a chamber used a plastic basket.

The fruits were analyzed every day until it is damaged which is characterized by wrinkling, softening, skin color becomes dull, the appearance of black spots on the skin of the fruit and seems mold (fungus) at the base of fruit and vegetables.

2.4. Observation Parameters

Observation parameters in this research were vitamin C, pH value, moisture, total acid, Total Soluble Solids, weight, colour (skin).

3. Results and discussion

3.1. Result

The result of this research showed that tomato could be stored in ZECC for 20 days, while on cold and ambient temperature storage it can only be stored for 15 and 10 days, respectively. The result showed that ZECC storage is an excellent method to extend the shelf life of tomato compared to cold and ambient temperature storage.

3.2. Discussion

3.2.1 Vitamin C

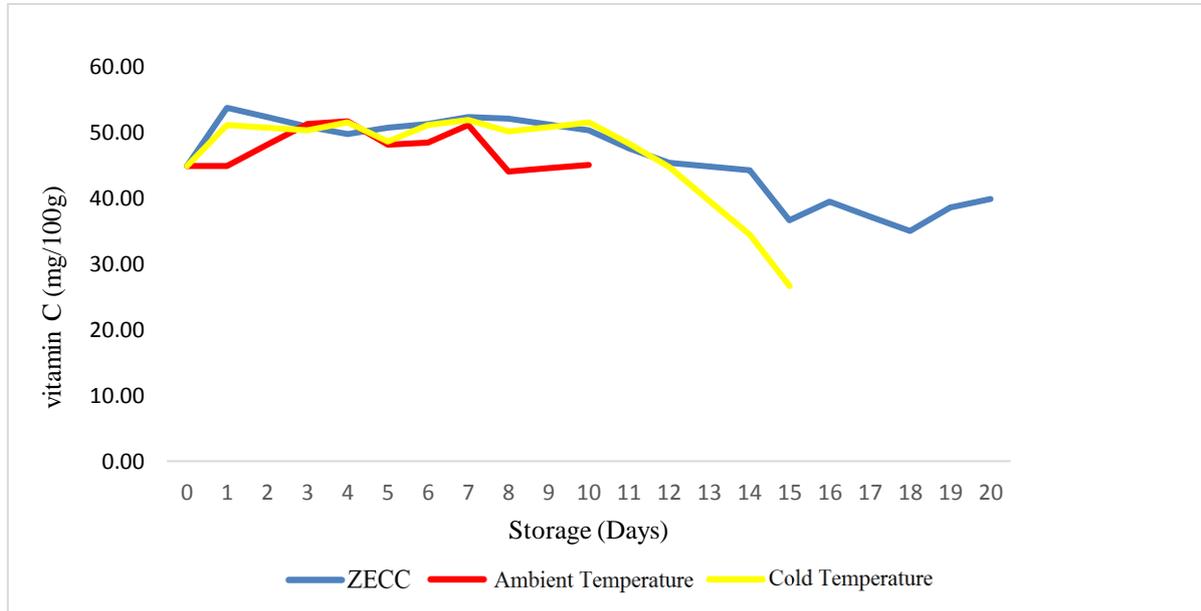


Figure 1. Vitamin C Content of Tomato during Storage

Vitamin C content of tomato during the storage was found diminished, however, the tomato that was stored using ZECC method showed a slower reduction compared to other methods. This is because the tomato stored in ZECC was not damaged due to cold and room temperature; therefore the tomato was not withered and wrinkled[9]. The result found in this experiment agreed with Islam in 2012 who stated that relative humidity in storage room can be related to durability and quality of a product in which when the air is dry, the moisture will be absorbed from the stored food caused withered and wrinkled[5].

3.2.2 pH

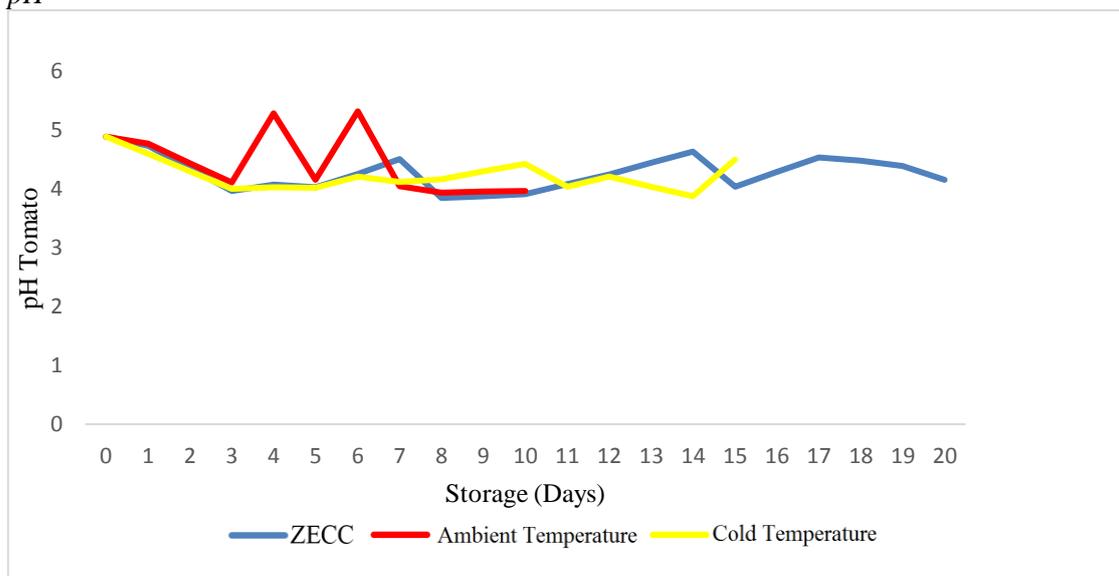


Figure 2. The pH of Tomato during Storage

The result of pH measurement of tomato during storage showed that by using ZECC method the pH was 3,84-4,88, while in cold storage the pH was 3,87-4,88, and for the ambient room storage, the pH was 3,96-5,31. The result of the pH measurement of tomato was varied every day. However, the pH tended to stable on 4 which categorized as acid, pH 4 on tomato indicated that the tomato is sour, the pH of tomato is influenced by the ratio of sugars and total acids. This stated by Dirpan in 2019 that pH measurement is correlated to the ripeness level of fruit because the ratio of sugar and acids generally indicates the fruit maturity[1].

3.2.3 Moisture Content

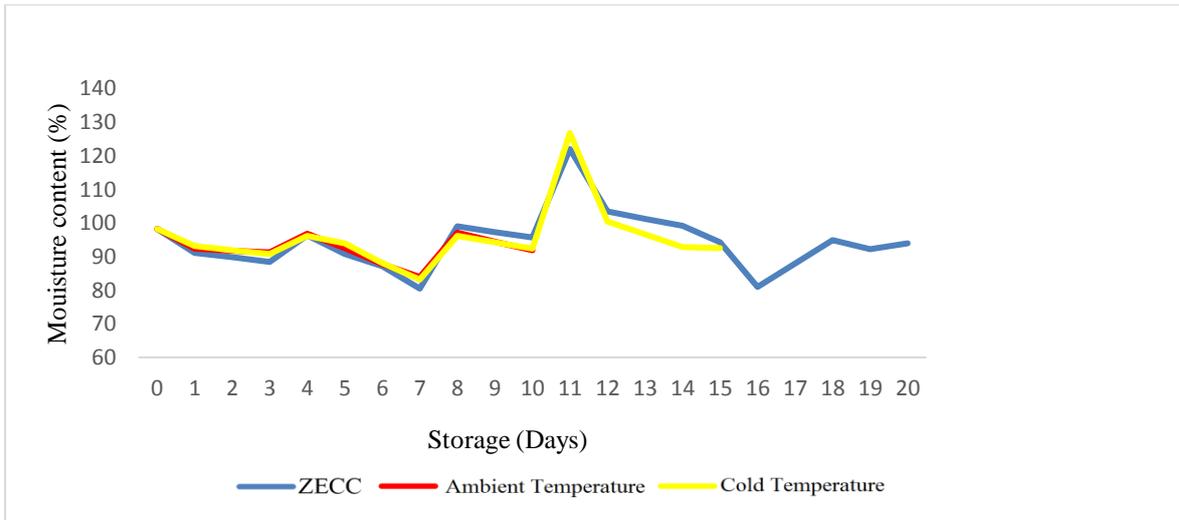


Figure 3. Moisture of Tomate during Storage

Tomato moisture during storage in different method was varied, even in the storage using ZECC method and cold storage on the 11th and 12th days resulted in an irrelevant result which was above 100%. In general, the tomato moisture will be decreased during storage following by weight shrinking. The moisture decreases of tomato during storage caused by transpiration and respiration. However, the instrument used in this experiment was not sufficient, thus the moisture obtained as depicted in figure 6. This is as stated by Dirpan in 2019 that the vegetables have high moisture so when it is not stored in cold condition, caused damaged of fruit resulted in fast withered due to partially evaporation[1].

3.2.4 Total acid

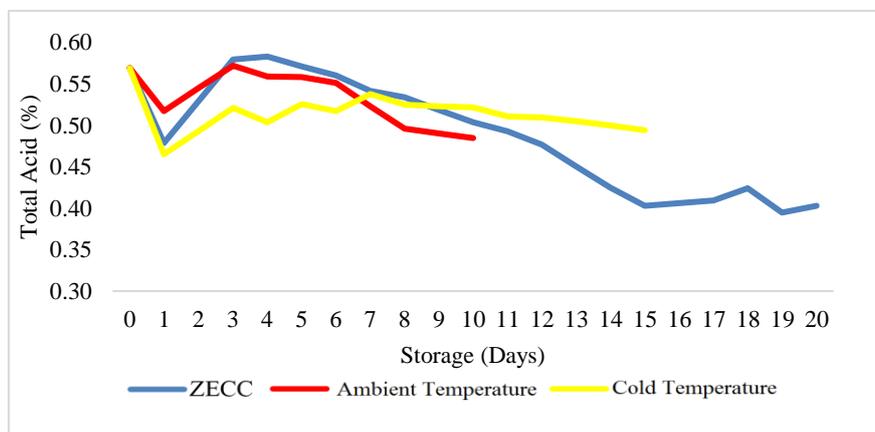


Figure 4. Total Acid content of Tomato During Storage

The total acid content of tomato during storage was decreased which was caused by chemical properties changing on tomato during the storage in which the organic acid is reducing due to maturity. In addition, the amount of citric and malic acid on tomato is around 60% of total organic acid in the fruit, during the ripeness the ratio of malic and citric acid is changed that indicated a conversion of malic to citric acid.

3.2.5 Total Soluble Solids

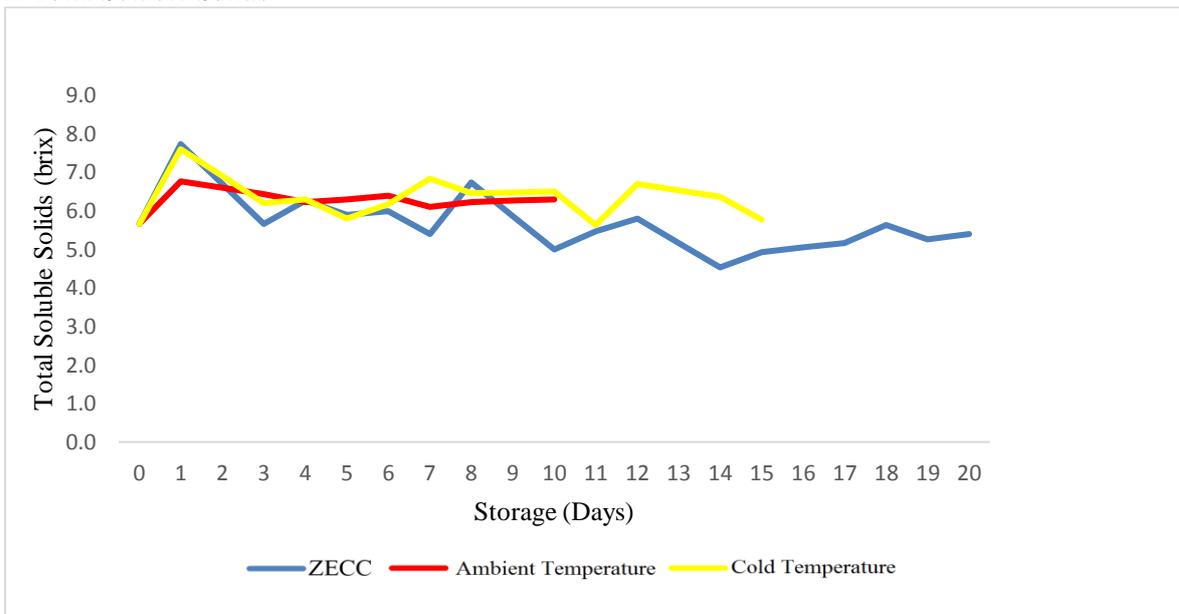


Figure 5. Total Soluble Solid Content of Tomaro During Storage

The result of the measurement showed that there was a similar trend in which we can see that the total soluble solid is firstly increase and followed by gradually decreasing during storage. The total soluble solid in the food when stored is tended to increase and followed by a decrease. Kays (1991) stated that the tendency of fruit and vegetable during storage is increasing in total sugar and followed by a decrease[10]. In which the sugar decreasing is following respiration trend.

3.2.6 Weight

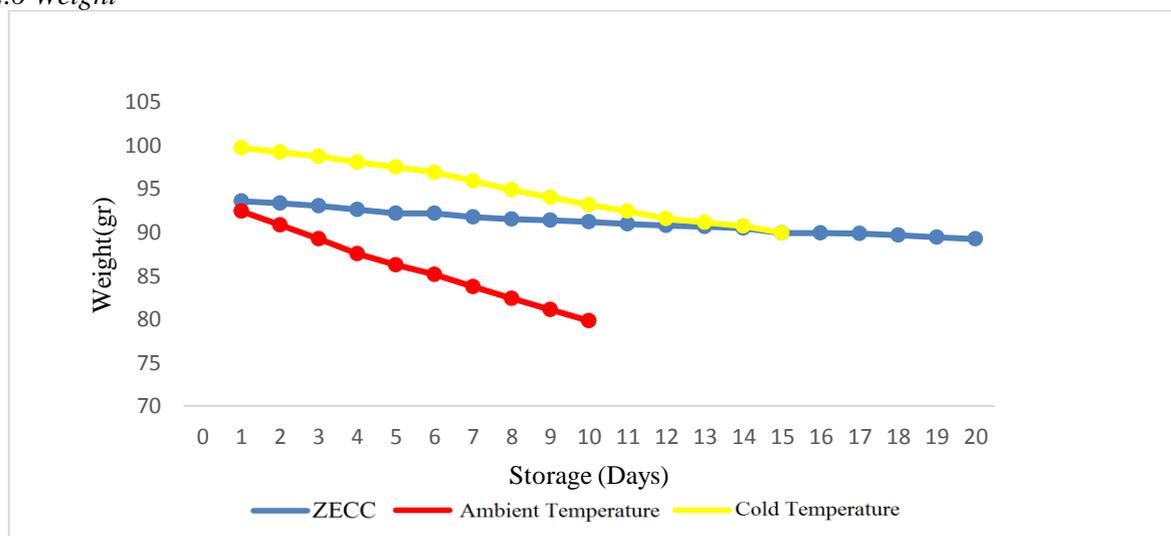


Figure 6. The weight of Tomato During Storage

Based on the Figure 6, We can see that the weight measurement of tomato during storage showed that ZECC method is the best result. The difference of weight loss of each method occurred due to the difference of temperature and RH during the storage. In ambient temperature, the temperature considered too high while in cold storage the temperature was too low and not appropriate RH that led to withered to tomato. As stated by Kays (2012) that that weight loss of fruit during storage is caused by transpiration and respiration that caused loss of moisture[10].

3.2.7 Colour

Based on figure 7 and 8 we can see that the tomato storage using ZECC method showed the best result. As can be indicated by red light color as well as no withered. The changes of color in tomato occurred due to chlorophyll degradation as well as withered that stored in ambient temperature due to ripeness. Besides that, a proper RH causes the less withered in mango that stored using ZECC method. As stated by Kays (2012) that during the maturity of fruit the changes of color is due to chlorophyll degradation. In tomato, the color changing is caused by chlorophyll degradation as well as lycopene synthesis. Also, in outdoor, the ripeness occurred much faster and the damages happened soon. Besides that, the moisture between 85-90% is needed to avoid withered and softening on fruit and vegetables,



Figure 7. Tomato ZECC, Cold Temperature, and Ambient Temperature Day 0



Figure 8. Tomato ZECC, Cold Temperature, and Ambient Temperature Day 20

4. Conclusion

The quality of tomatoes after storage at ZECC is as follows: vitamin content 39.95 mg / 100g, pH 4.15, total acid 0.40, total dissolved solids 5.4⁰Brix, weight loss 4.66 grams. Also, tomatoes can be stored at ZECC for 20 days, storing cold temperatures for 15 days, and storing room temperature for 10 days.

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