Study of the Quality of Zalacca Fruit on Control Atmosphere Storage (CAS) and Modified Atmosphere Packaging (MAP)

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Abstract. Zalacca fruit has a short shelf life which is about 5-7 days after harvest. Control Atmosphere Storage (CAS) and Modified Atmosphere Packaging (MAP) are alternative technologies that can be applied to increase the shelf life of fruit. In the CAS system, zalacca fruit was stored in a room with a composition of 9% O2 and CO2, a temperature of 8-12°C, and 90% RH, while in the MAP system the fruit was packed in plastic crates in a capacity of 8 kg then the crates are coated with plastic which is given holes as many as 72 holes measuring 0.5 cm. The results showed that zalacca fruit can be stored in CAS conditions for 26 days with a weight loss of 1.25% and a damage level of 7.3%, while the weight loss and damage levels of zalacca fruit on MAP storage were 2.6% and 29.5%. Microscopically the fruit of zalacca CAS and MAP showed skin wrinkling which was thought to be related to the occurrence of water loss during storage. Based on the data obtained, the storage of zalacca fruit by CAS was more effective than MAP.

1. Introduction
Zalacca fruit is one of the horticultural product that has good potential to export. Besides having good nutritional content, zalacca fruit contains bioactive components that provide health effects. Previous research explained that there was positive correlation between the consumption of fruits naturally rich in antioxidants and a lower occurrence of non-communicable diseases including cancer, cardiovascular disorders and diabetes [1, 2, 3]. However, zalacca fruit is perishable thus has a short shelf-life. Research showed that self life of zalacca fruit was only 5-7 days in ambient condition after harvested[4]. With a short shelf life, it becomes difficult for zalacca fruit to be marketed more widely, especially for export, which takes a long time by sea. For this reason, post-harvest technology to extend the shelf life of zalacca fruit needs to be applied.

Control Atmosphere Storage (CAS) and Modified Atmosphere Packaging (MAP) are the potential techniques to increase the shelf life and maintain the quality of zalacca fruit. In CAS and MAP, the environmental conditions for storing fruit were modified so that the concentrations of O2 and CO2 were different from normal conditions, ie the O2 content was suppressed while the CO2 concentration was increased. CAS and MAP cause fruit respiration to be suppressed so that the fruit has a longer shelf life and quality can be maintained [5].

The purpose of this study was to determine the effect of CAS and MAP storage on the shelf life of zalacca fruit. The information obtained will be used as a basis for recommending appropriate technology to extend the shelf life of the zalacca fruit so that it has the opportunity to increase its marketing both domestically and exports.

2. Materials and Methods
The materials used in the study were Salacca zalacca var. pondoh fruit with a maturity level of 70% obtained from magelang area and red galangal. The research stages included harvesting, precooling (aerating), sorting and cleaning (brushing the skin), immersing in 5% water extract galangal, draining (spreading and blowing air using a blower), storing using CAS applications on the composition of O2 and CO2 9% and MAP using PE plastic 0.05 with 72 perforated holes 0.5 cm in diameter combined
with a temperature of 8-12°C, and 90% RH for 26 days. Each storage system has a capacity of 8 kg with 3 replications. Fruit quality parameters observed included weight loss, and percentage of damage, water content of skin and fruit, total soluble solids (TSS), and microscopic structure of skin and flesh the fruit. TSS was measured by crushing the zalacca pulp then taking the liquid (juice) and dropping it on the surface of the refractometer, view the juice through light, and match the blue colour shown on the scale to a chart. The microscopic structure was observed using a binocular microscope at a magnification of 100 times.

**Figure 1.** Equilibrium condition of zalacca fruit

**Figure 2.** Storage of zalacca in CAS (a) MAP system (b)
3. Results and Discussion

3.1 Weigh loss and damage

Zalacca fruit with CAS storage showed lower weight loss and damage percentage compared to MAP storage. The level of zalacca fruit damage between the CAS and MAP systems appeared to be quite significant, where the damage of the zalacca fruit with the CAS system was 7.3%, while the storage of zalacca by MAP showed a damage rate of 29.5%. The high level of zalacca fruit damage in the MAP storage system is due to the higher humidity in the packaging compared to the CAS system, which triggers mold growth which causes damage and fruit rot. Damage due to mold attack can be seen from the discovery of mold mycelia on the fruit.

| Treatments | Weigh loss (%) | Damage (%) |
|------------|----------------|------------|
| CAS        | 1.25           | 7.3        |
| MAP        | 2.60           | 29.5       |

Figure 3. Microbial attack on zalacca fruit during storage

3.2 Water content

The water content of zalacca with MAP treatment had a slightly higher moisture content in the skin and flesh than that of the salak fruit with CAS treatment. In the MAP system, the fruit is stored in porous packaging, causing a modified environmental condition, especially the air composition. The rate of respiration in the packaging environment is still quite high and changes occur during storage. In addition, the presence of packaging also causes water vapor as a result of respiration and transpiration of fruit to be partially trapped in it, so that the environment becomes humid. This causes the skin of the fruit to become more watery. In the CAS system, environmental conditions are maintained stable during storage, so that during storage the respiration process becomes more constant. This can be seen by the absence of dew formation in the environment.

Similar to the skin, the MAP zalacca flesh showed a slightly higher water content compared to the water content of the CAS zalacca fruit flesh. This can be influenced by the activity of changing the starch and sugar which is faster in the MAP zalacca than the CAS salak.

| Treatments | Water content of zalacca fruit skin (%) | Water content of zalacca fruit flesh (%) |
|------------|----------------------------------------|----------------------------------------|
|            | Before storage                          | After 26 days storage                  | Before storage                          | After 26 days storage                  |
| CAS        | 54,46±8.44                             | 70,38±2,11                             | 79.24±0.6                               | 80,37±0,66                             |
| MAP        | 54,46±8.44                             | 72,61±3,23                             | 79.24±0.6                               | 81±0,52                                |
3.3. Total soluble solute (TSS)
TSS of zalacca tended to decrease after storage, both for the fruit stored as CAS or MAP. The higher activity of starch and sugar breakdown in the zalacca fruit stored in MAP could also be indicated by the lower TSS value compared to the zalacca fruit stored in CAS at the end of storage. During storage under normal conditions, the fruit undergoes changes in the composition of sugars and acids which have implications for changes in texture. CAS can suppress changes in sugar, acid and fruit texture [6].

| Perlakuan | Before storage | After storage |
|-----------|----------------|---------------|
| CAS       | 19,4±0,94      | 17,47±1,11    |
| MAP       | 19,4±0,94      | 16,93±0,38    |

3.4. Visual appearance of salak fruit

Visually, salak fruit stored in CAS showed a better appearance compared to MAP. The skin of the zalacca fruit looked fresh on the zalacca fruit stored in CAS, while the skin of the zalacca that was stored in MAP showed a darker part of the skin color (Figure 4b). Similar symptoms were also found in previous studies, where there was the formation of brown spots on the skin of the zalacca fruit which was given a coating treatment combined with MAP packaging using LDPE plastic[7]. Research explained that brown spot on the skin of zalacca fruits indicate Thielaviopsis attack, which is one of the fungi that is the main cause of the fruit rot[8]. The higher water content in the MAP-packed zalacca fruit as well as the MAP environmental conditions which were more humid and richer in oxygen can trigger fungal growth on the surface of the fruit.

The results also showed the white zalacca flesh on the zalacca fruit stored in CAS. In some case, reducing O₂ can reduce oxidative browning reaction. Reduced O₂ level can delay compositional changes such as fruit pigment development, softening, hardening of some vegetables (such as asparagus and broccoli), and development of flavor due to a decrease in the activity of oxidative enzymes such as glycolic acid oxidase, ascorbic acid oxidase, and polyphenol oxidase[5].

![Figure 4](image-url)
3.5. Microscopic appearance

In zalacca, skin characteristics are one of the parameters for consumer acceptance. In general, consumers do not like salak fruit with dry skin because it becomes difficult to peel. Microscopically, salak fruit skin with CAS storage did not show significant changes compared to salak after harvest. However, the salak fruit with MAP storage showed denser skin scales and indicated cavity formation (Figure 5c).

Figure 5. Microscopic structure of zalacca skin after harvest a), after CAS storage b), after MAP storage c) at a magnification of 100 times using a binocular microscope

Figure 6. Microscopic appearance of zalacca flesh after harvest a), after CAS storage b), after MAP storage c) at a magnification of 100 times using a binocular microscope

Microscopic observation of the zalacca flesh showed a structure that did not change much in the zalacca stored as CAS or MAP. This explains that both CAS and MAP storage techniques can maintain quality and increase the shelf life of zalacca.

4. Conclusions

1. Zalacca fruit quality can be maintained by storing it in CAS or MAP
2. CAS storage technique is more effective than MAP. Zalacca fruit damage during 26 days of storage in the CAS system was only 7.3%, while with MAP it caused damage up to 29%.
3. In the water content parameters as well as the TSS, the changes show the same pattern of changes, but quantitatively the changes in the MAP show higher values.

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