Low temperature and duration on quality of fig fruit (*Ficus carica* L.)

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**Abstract.** This study aims to determine the effect of low temperature and storage duration as well as the interaction of both to the quality of figs (*Ficus carica* L.). This study used a Split Plot Design factorial pattern 3 x 3 with 3 replications, each of 27 experimental units used 3 fruits so that the total number of figs used is 81 fruits. Storage temperature as main plot consisting of 3 levels (5 °C, 10 °C and 15 °C) and storage duration as sub plot consisting of 3 levels (3 days, 6 days and 9 days) was employed as factors in this study. The results showed that storage temperature had a very significant effect on weight loss as well as significant effect on antioxidant and total dissolved solids. Storage duration had a significant effect on weight loss, water content, antioxidant activity, L-a-b value of color as well as on total dissolved solids. Significant interaction effect of both factors was observed in weight loss, water content, and antioxidant activity. The study found the best condition for maintaining quality of fig when the fruit is stored in a temperature of 5 °C and for a duration of 3 days.

1. **Introduction**

Figs contain alkaline-like substances that function to eliminate acidity in the body, treat external wounds, stimulate the formation of blood haemoglobin, and contain high glucose levels without causing diabetes [1]. Figs can also prevent stomach cancer [2]. Leaves of fig plants have various active ingredients such as flavonoids, phenolics, coumarin, glycosides, steroids, and triterpenoids [3].

Figs are a horticultural commodity that is generally consumed fresh. One of the problems in horticultural commodities is improper post-harvest handling, which results in damage to fruit quality. Postharvest horticultural commodities are living products that are still actively carrying out their metabolic activities, this is characterized by the respiration process that is still running as before the product is harvested. The diversity of postharvest respiration rates is often used as an indicator of the rate of decline of the product. The higher the rate of respiration the faster the rate of decline and the faster the death that occurs [4].

The degradation that occur in the post-harvest yield of horticultural crops can be overcome by proper postharvest treatment, including low temperatures storage [5]. The use of low temperatures requires proper temperature settings. Temperature settings is one of the important factors to increase shelf life and freshness of fruit [6]. Storage at low temperatures can inhibit the activity of...
enzymes and chemical reactions and inhibit or stop the growth of microbes [7]. The purpose of low temperature storage (10 °C) is to prevent damage without causing undesirable changes such as decay [8].

In addition to storing fruit at low temperatures, the storage duration of fruit is also an important factor to maintain the quality of fruit freshness. Storage also means an effort to maintain commodity yields remain in fresh condition while still having good quality. In Garcia [9], it was mentioned that Cuello de Dama varieties fig grown in Spain can last 7 to 10 days with the best storage of 6 °C using plastic film (wrap plastic) which is slightly given a hole. This can be seen from the higher dissolved solid value and also sensory analysis which consists of taste, freshness and texture. In Jadhav and Gurav [10] the best storage of fig varieties of Poona grown in Maharashtra, India is at 4 °C with humidity reaching 93% and maintaining a maximum storage period of 6 to 9 days. Based on this description, it is necessary to study the effect of low temperature and storage duration on the quality of Black Jack figs varieties grown in Aceh, Indonesia. The purpose of this study was to find out the ideal temperature and storage duration on the quality of fig fruit to store Indonesian.

2. Materials and Methods
2.1. Time and place of research
This research was conducted at the Horticulture Laboratory of the Agrotechnology Department and the Laboratory of Food and Agricultural Product Analysis of the Agricultural Product Technology Department, Faculty of Agriculture, Syiah Kuala University, Banda Aceh, from June to September 2019.

2.2. Tools and materials research
2.2.1. Tools. The tools used in this study were analytical scales (Electronic Balance type JP2-160), digital scales (Chyo MJ-6000), refrigerators (Sharp and Electrolux), thermometers, knives, ovens (Memmerk), refractometers (ATC), spectrophotometers (ATC), spectrophotometers (ATC) Shimadzu UV-1700 pharma spec), vortex (Gemmy mixer VM model: 300p), measuring cups, beaker glass, test tubes, porcelain cups and cameras (Nicon D7000).

2.2.2. Materials. The materials used in this study were freshly harvested figs, Black Jack varieties obtained from the Experimental Garden of the Faculty of Agriculture, Syiah Kuala University and harvested at the plant age of 9 months with physiological ripe fruit with reddish purple fruit and harvested fruits amounted to 81 pieces. Moreover, the styrofoam sized 12 cm x 18 cm, plastic cling wrap, 2,2-diphenyl-1-picrylhydrazyl (DPPH) powder and ethanol were used.

2.3. Experimental design
The design carried out in this study was a Split Plot Design factorial pattern 3 x 3 with 3 replications consisting of 2 treatment factors namely, low temperature factor (S) and duration of storage (P). Low temperature as the main plot (main plot) and long storage as sub-plots. Low temperature factor (S) consists of 3 levels, namely: S1 = 5 °C, S2 = 10 °C and S3 = 15 °C. The storage time factor (P) consists of 3 levels: P1 = 3 days, P2 = 6 days and P3 = 9 days. From these three factors, 9 treatment combinations were obtained so that the total treatment total was 27 experimental units. In each treatment combination used as many as 3 figs so that the total figs used were 81.

2.4. Research Parameters
Observations were made at each treatment. The observed changes show the effect on the shelf life of figs, including:
2.4.1. Weight Loss (%) [11]. The weight loss is observed by comparing the difference between the initial weight and the final weight. This method is called the gravimetric method. The initial weight is obtained from the weighing of the fig weight before packaging, while the final weight value is obtained from the weighing of fig weight after storage at low temperatures for 3, 6 and 9 days.

2.4.2. Water Content (%) [12]. One method of determining water content that is simple and widely used for food products is the drying method or the oven method. The first step is to refine the fig in porcelain cups using pastille. Then the sample was weighed as much as 5 g with analytical scales, then put in a cup that had previously been dried in an oven at 75 °C for 15 minutes and cooled in a desiccator for 10 minutes then weighed and known for its weight. Then the sample and the cup are dried in an oven at 105 °C for 3 hours and cooled in a desiccator for 15-30 minutes.

2.4.3. Antioxidant Test (%) [13]. The procedure for testing antioxidant activity is the DPPH (2,2-diphenyl-1-picrylhydrazyl) Radical Scavenging Method. Each sample is mashed and weighed to obtain a weight of 1 gram and then put into a measuring cup. Then put 50 ml of ethanol into a measuring cup and stirred using a stirrer until the color changes in ethanol. Next weighed DPPH 0.0098 gr powder, then ethanol 200 ml was added. Samples that have been filtered before are taken 0.2 ml and put into test tubes then added with 3.8 ml DPPH solution. The sample was then vortex and incubated in a dark place for 30 minutes. Then vortex again, then read the absorbance with a spectrophotometer at λ = 517 nm. Ethanol is used as a blank with the same treatment as the sample.

2.4.4. Dissolved Total Solids (Brix) [14]. The total dissolved solids can be calculated using an abbe refractometer. The TPT content can be read in Brix units. Before using the tool, first clean it with alcohol and wipe it dry. The sample to be measured is placed sufficiently at the reading place. Then the TPT value will be indicated by the number obtained at the boundary of the blue and white lines.

2.4.5. Color [6]. Color measurements are determined based on digital data with the intensity levels of white (L), red (a), yellow (b) taken with the camera (Nicon D7000). L, a and b values are then viewed using the Adobe Photoshop CS6 application. L values indicate brightness [L = 100 (white) and L = 0 (black)], values a indicate red when positive, gray when 0, and green if negative. While the value of b shows yellow when positive, gray when 0, and blue when negative.

3. Results and discussion

3.1. Effect of temperature on the quality of figs

Table 1 shows that temperature has a significant effect on the weight loss of figs. The lower the temperature was the lesser the weight loss. Shrinkage of weight at 5 °C is less when compared to 10 °C and 15 °C. This is apparently occurred because the figs at 5oC are slower to evaporate due to transpiration compared to 10 °C and 15 °C. In Khan et al. [15] states that weight loss in fruit is not caused by the evaporation of water alone but also due to loss of CO₂ gas from respiration. Water loss during storage not only reduces weight, but also reduces quality and causes damage. Muchtadi [16] also stated that storage at a low temperature of 5°C can reduce the speed of respiration and transpiration so that the process of weight loss is slow and the fruit storage can be extended. The increase in temperature makes the rate of respiration will occur more quickly, where each increase of 5°C-10°C can increase respiration rate 2 to 3 times. The highest water content was found in the treatment of 15 °C, although statistically different was not significantly different from other treatments.

Table 1 shows that figs stored at 15 °C has the highest antioxidant activity compared to other figs stored in 5 °C and 10 °C. In the preliminary observation, before the figs were put into the refrigerator, the antioxidant activity was 16.76%. So that, antioxidant activity only reduced 0.51% for figs stored at 15oC. In general, lower temperatures can inhibit decreased antioxidant activity. This is in line with Rahmawati [17], that the low temperature of 4 °C is able to reduce the activity...
of free radicals in leaves better than the high temperature of 35 °C. Storage at low temperatures also causes a smaller decrease in antioxidant activity [18].

Table 1. Effect of storage temperature on quality of figs.

| Parameter                        | Temperature (ºC) |
|----------------------------------|------------------|
|                                  | $S_1$ (5)        | $S_2$ (10)   | $S_3$ (15)   |
| Weight Loss (%)                  | 1.84 a           | 2.40 b       | 2.74 c       |
| Water content (%)                | 80.94            | 80.76        | 81.99        |
| Antioxidant (%)                  | 14.90 a          | 15.40 ab     | 16.25 b      |
| Total Dissolved Solids (Brix)    | 17.15 b          | 16.10 a      | 15.78 a      |
| Colour: - L                      | 14.05            | 13.59        | 13.73        |
| - a                              | 15.37            | 15.17        | 14.84        |
| - b                              | 7.54             | 7.67         | 7.07         |

In the study of Zegarac and Samec [19], berries stored at low temperatures of 4 °C showed high stability for up to 15 days compared to room temperature of 25 °C. This shows that low temperatures can maintain the antioxidant activity in berries. Whereas in this study, the optimal low temperature for the antioxidant activity of Black Jack variety was 15°C compared to other low temperatures used in this study. In this case, the current study is slightly different from existing theories. This is presumably because there are differences in fruit types and because of the negative working principle of the refrigerator at temperatures that are too cold, in this case 5 °C and 10 °C, so that the best fig antioxidants are found at 15 °C.

In Table 1 the highest total dissolved solid of fig obtained at 5 ºC was significantly different from 10 ºC and 15 ºC. This is presumably because the low temperature of 5ºC can suppress the rate of respiration which will result in decreased fruit sugar content. Total dissolved solids were measured to find out the sugar content in the fruit. In Khan et al., [15] states that sugar is an important substance in dissolved solids so that the total dissolved solids of fruit can be measured by looking at the sugar content of the fruit. Purnomo et al., [20] states that starch which is a source of energy in the process of respiration will be hydrolysed into simple compounds during cooking. Then the sucrose that is formed will break into glucose and fructose. Some glucose will be used in the process of respiration.

Lower temperatures can reduce the rate of respiration, so the use of sugar for the respiration is less when compared to higher temperatures. The decrease in the percentage of total dissolved solids during storage at temperature 5 ºC can be suppressed because at low temperatures the rate of respiration can be inhibited so that the use of sugar for the process of respiration is less. Therefore, the total dissolved solids obtained at a temperature of 5 ºC is higher than the total dissolved solids at temperature of 10 ºC and 15 ºC.

The highest L (brightness) and colour a (Red) of figs was found at 5 ºC, although it was not significantly different from other temperatures. While the highest value of b (yellow) was found at 10 º C, although it was not significantly different from other treatments.

3.2. Effect of storage duration on the quality of figs

In Table 2 the highest weight loss percentage was obtained by 9 days storage, it was significantly different from 3 days and 6 days storage. The storage duration has a significant effect on the weight loss of figs, that the longer the storage duration, the higher the rate of weight loss. The greatest weight loss occurred when the figs were stored at 9 days, then it decreased at 6 days storage duration and followed by 3 days storage duration. Thus, 3 days storage duration as the shortest duration could prevent weight loss better than others. This is supported by in Purnomo et al., [21] which states that the longer the fruit is stored, the greater the weight loss. Weight loss will increase due to the storage time. The longer the fruit is stored, so the water content in the fruit decreases.
The decreased of water content caused the weight loss. During storage, weight loss cannot be prevented. This happens because of the physiological processes of respiration and transpiration. Increase in weight loss is also thought to occur due to the high rate of respiration that is still and continues [22].

### Table 2. Effect of storage duration on the quality of figs.

| Parameter                        | Storage Duration (Days) |           |           |
|----------------------------------|-------------------------|-----------|-----------|
|                                  | P 1 (3 days)            | P 2 (6 days) | P 3 (9 days) |
| Weight Loss (%)                  | 1.42 a                  | 2.49 b    | 3.06 c   |
| Water content (%)                | 82.95 b                 | 80.82 a   | 79.92 a   |
| Antioxidant (%)                  | 16.58 b                 | 17.26 b   | 12.72 a   |
| Total Dissolved Solids (Brix)    | 15.87 a                 | 17.05 b   | 16.11 a   |
| Colour: - L                      | 10.00 a                 | 16.94 c   | 15.24 b   |
| - a                              | 12.62 a                 | 16.22 b   | 16.56 b   |
| - b                              | 7.54 b                  | 3.78 a    | 9.13 c    |

#### 3.2.1. Weight Loss

The figs stored in 3 days significantly has the highest water content compared to 6- and 9-days storage. The longer the fruit is stored, the less water content is stored. The lowest water content is obtained after the figs being stored for 9 days. Water content is inversely proportional to weight loss. The smaller the value of the weight loss, the higher the value of water content owned. Water content is also inversely proportional to the storage duration. The longer it is stored; the less water it has in the fruit. This is caused by the fruit undergoing the process of transpiration. To get the best fruit quality based on water content with a short shelf life, in this study the best shelf life of figs is 3 days.

#### 3.2.2. Water content

The highest antioxidant activity was obtained by 6 days storage that was significantly different from 9 days storage but was not significantly different from 3 days storage. In this study the best storage time for figs to maintain their antioxidant activity was 3 to 6 days. This is presumably because figs are able to maintain levels of betacyanin (the pigment that gives yellow, red, orange, purple to the leaves and fruit) until it reaches 6 days and decreases the next day. In the research of in Nataliani et al. [18] dragon fruit meat has decreased antioxidant activity along with the length of storage time. Decreased antioxidant activity occurs along with decreased levels of betacyanin which decreases due to the influence of several factors during storage such as oxygen, light and temperature exposure. As a result of decreased betacyanin levels, the ability of the dye solution to reduce DPPH free radicals is also marked by a decrease in absorbance when tested using a spectrophotometer.

#### 3.2.3. Total Dissolved Solids

The highest total dissolved solid was obtained when the figs are stored for 6 days, which was significantly different from the storage time of 3 days and 9 days. The highest total dissolved solid comes from storage for 6 days followed by storage for 9 days and the lowest is storage for 3 days. This is happened because until the storage time up to 6 days the figs are still ripening that caused the total dissolved solids to become higher but then it decreases in the following day.

#### 3.2.4. Color

In Arifiya [23] in the mango fruit obtained the highest total dissolved solids in the storage treatment for 14 days and followed by storage for 7 days. The pattern of improvement is a characteristic of climatic fruit where the fruit at an advanced level has the highest total soluble solid content due to the hydrolysis of starch to sugar and will touch the climatic peak [24]. According Winarno-Aman [25] states that the increase in total dissolved solids is caused by the hydrolysis of starch which is not soluble in water to sugar which is soluble in water. Respiration also continues
during the process of maturation to aging, while only a little starch has the sugar dissolved in water is oxidized to conduct respiration. Furthermore, in Winarno [25] also stated that the increase in the total value of dissolved solids was caused by hydrolysis of carbohydrates into glucose and fructose compounds while the decrease was caused by simple sugar levels that turned into alcohol, aldehydes, and acids. However, in the present study on figs, the best total dissolved solids of figs were with a storage period of 6 days and a slight decrease in the total value of dissolved solids at 9 days.

Table 2 shows that the highest brightness value obtained at 6 days treatment was significantly different from the 3 days and 9 days treatment. This means that figs have the highest brightness when stored for 6 days This is allegedly due to the formation of brightness that occurs during storage. The highest red color was obtained after the fig had been stored for 9 days and was not significantly different by 6 days but was significantly different from 3 days. The values indicate the color chromatic red green. The higher the value of ‘a’ in the color of the fruit, the redder the color of the fruit [26-29] the highest value of color b (yellow) was obtained at 9 days treatment that was significantly different from the 3 days and 6 days treatment. This means 9 days of storage can increase the value of b. The high color of b (yellow) indicates that the yellow value is more dominant than the blue color (if the color b indicates a negative value). Yellow means that the fruit is ripe. This is in accordance with Mardiana [27] which states that yellowish fruit is ripe fruit. This shows that the yellow color can last up to 9 days despite a slight decrease in numbers on day 6.

4. Conclusion
The temperature has significant effect on figs quality during the storage. The figs stored at 5 ºC has the best quality based on the lowest weight loss and the highest total dissolve dissolved solids. Furthermore, the storage duration also has significant effect, which the best duration to maintain the quality of figs is at 3 days. At that duration, the figs have the lowest weight loss and the highest water content. The figs especially Black Jack variety can maintain the best quality when it is stored at temperature of 5 ºC for 3 days.

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