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Effect of Ozone Treatment on Vitamin C Levels of Strawberry (Fragaria x ananassa) with different storage temperatures

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***Abstract*— Strawberries contain many nutritional values that are good for the health of the body, one of which is vitamin C. Fresh strawberries contain high levels of vitamin C. During storage, it is easily oxidized because it is unstable, causing a decrease in vitamin C levels. The unstable nature of vitamin C is a problem that needs attention and proper postharvest handling is given to maintain the vitamin C content in strawberries. The purpose of this study is to maintain the vitamin C content of strawberries after storage by using ozone water immersion treatment with different storage periods. The research method used is a factorial Completely Randomized Design with a factorial pattern. The first factor is ozone (0 ppm, 0.05 ppm, 0.08 ppm, and 0.1 ppm). The second factor is fruit storage temperature (27°C and 10°C). The results showed that during storage of strawberry vitamin C there was an increase and decrease. The initial content of vitamin C in strawberries used is 927.13 mg/100g, increased to 1350.03 mg/100g in the ozone treatment of 0.05 ppm at 10°C storage and decreased to 0.08 ppm ozone treatment at 10°C storage to 848, 39mg/100g. The best treatment that can maintain vitamin C levels and increase vitamin C levels during storage is treatment with 0.05 ppm ozone with 10°C storage.*

Keywords*— Ozone, Strawberries, and Vitamin C.

I. INTRODUCTION

Strawberry fruit is bright red fruit, has a distinctive aroma, tastes fresh, and has a relatively expensive price, making strawberries popular and highly prestigious [1]. Strawberries have many health benefits and also contain a lot of nutritional value such as vitamin C, flavonoids, anthocyanins, activity, and antioxidants [2]. Vitamin C has unstable properties so that it is easily oxidized when exposed to air (oxygen) and causes the vitamin C content to decrease [3]. Vitamin C contains a hydroxy functional group (OH) which is very reactive in the presence of an oxidizing hydroxy group so that oxidation occurs to a carbonyl group [4]. The unstable nature of vitamin C during the storage process of strawberries is an important problem that needs to be addressed.

During storage, vitamin C can undergo a degradation process when the room temperature increases. The degradation process can occur, vitamin C can occur and continue to increase if there is an increase in temperature of 10 °C [5]. A decrease in vitamin C can also be due to respiration and transpiration that occur after harvesting. Respiration is a process of renovation of organic material from carbohydrates, fats, and proteins into CO_2 and H_2O [6]. The respiration process that takes place causes physiological changes in the fruit in the form of a decrease in quality in terms of weight loss, taste, color, decreased vitamin content, and wilting [7]. One way that can be done is by providing ozone treatment. Ozone (O_3) is a strong oxidant that can be used as a disinfectant to kill microorganisms and can be used as a means of control in post-harvest results that are safe for the environment [8].

Ozone molecules can kill microorganisms that cause rot by reacting with oxidized cellular components, especially if these microorganisms contain double bonds, sulfhydryl, and phenolic ring groups [9]. People usually coat the fruit with wax or use fungicides to prolong the shelf life of the fruit, but this treatment can hurt human health when consumed. Researchers are interested in conducting this research as another alternative in postharvest handling of strawberries and are safer when consumed.

II. METHODS

2.1 Strawberry Fruit Preparation Sample

Fig 1. Strawberry fruit collection

Strawberries are harvested in the morning with 3/4 maturity. The harvested fruit is then brought to the shade and sorted to separate the unfit fruit such as bruises/wounds, pests/diseases, and rot. The strawberries used are free from mechanical damage and have no rotten parts. The size of the fruit and the shape of the strawberry fruit are uniform. As many as 144 strawberries have been selected and then cleaned and cleaned of adhering dirt.

2.2 Ozone water immersion treatment

Ozone water immersion treatment was carried out with various concentrations, including 0 ppm, 0.05 ppm, 0.08 ppm, and 0.1 ppm. The ozone generator used in this study is the Dielectric Barrier Discharge Plasma (DBDP). Before ozone immersion treatment, 120 strawberries were taken and 36 fruits were taken for ordinary water washing (0 ppm ozone). As many as 108 strawberries were then divided by 3 for the treatment of various concentrations of ozone (0.05 ppm; 0.08 ppm and 0.1 ppm) to 36 fruits per concentration. Soaking strawberries at each concentration of ozone water is for 6 minutes

2.3 Analysis of Vitamin C Content.

Samples of strawberries were weighed as much as 0.25 g and dissolved with 0.5% oxalic acid to 25 ml. The sample was then filtered with filter paper and followed by a 0.45 m Minisart RC membrane filter and the sample was ready to be tested by HPLC. In this test methanol: oxalic acid (27:73) was used as the mobile phase, a 100-5 C-18 Merck KGaA Nucleosil column, a UV detector at a wavelength of 243 nm and a flow rate of 0.5 ml per minute [10].

2.4 Experimental Design

This research is an experimental study conducted in a laboratory using a factorial completely randomized design. The first factor is ozone treatment with 4 concentrations, namely O_0 (0 ppm), O_1 (0.05 ppm), O_2 (0.08 ppm), and O_3 (0.1 ppm). The second factor is 2 treatments of cold storage (T_{10}) and room temperature (T_{27}). Each treatment was repeated 3 times, while the treatments are given were O_0T_{10}: 0 ppm ozone for storage temperature of 10°C; O_1T_{10}: ozone 0.05 ppm storage temperature 10°C; O_2S_{10}: ozone 0.08 ppm storage temperature10°C; O_3S_{10}: ozone 0.1 ppm storage temperature 10°C; O_0T_{27}: ozone 0 ppm storage temperature 27°C; O_1T_{27}: ozone 0.05 ppm storage temperature 27°C; O_2T_{27}: ozone 0.08 ppm storage temperature 27°C and O_3T_{27}: ozone 0.1 ppm storage temperature 27°C

2.5 Statistic Analysis

The result from the analysis of vitamin C levels obtained will be analyzed using ANOVA (Analysis of Variance) using the SPSS 22.0 application with a confidence level of 95. If there is a significant difference, the test will be continued using Duncan's Multiple Range Test.

III. RESULTS

ANOVA analysis conducted with a 95% confidence level on the vitamin C content of strawberries showed that ozone treatment and storage temperature affected vitamin C levels in strawberries (Sig< table 0.05). An interaction occurs between ozone treatment and storage temperature (Sig< 0.05). The DMRT further test carried out showed that the interaction of ozone treatment and storage temperature had a significant effect on each treatment (Fig.1)

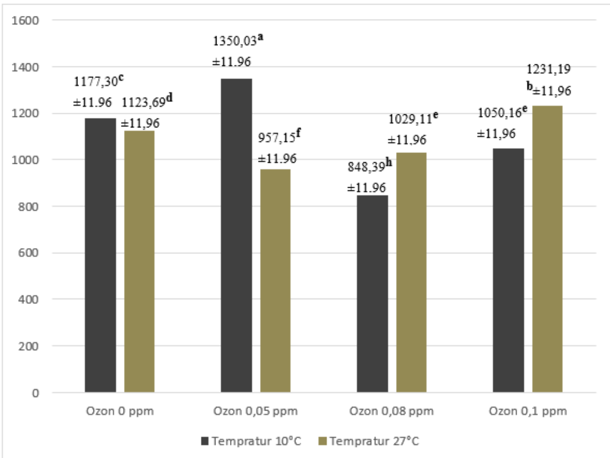

Fig 2. Histogram of the interaction between the ozone water leaching concentration factor and storage treatment on the vitamin C content of strawberries

The highest vitamin C content was obtained by ozone treatment of 0.05 ppm in cold storage (10°C) with vitamin C content of 1350.03 mg/100g. Ozone treatment of 0 ppm in cold storage has a higher vitamin C content of 4.55% than storage at room temperature. Ozone treatment of 0.05 ppm in cold storage had higher levels of vitamin C than storage at room temperature with a difference of 29.10%. Ozone treatment of 0.08 ppm at room temperature had higher levels of vitamin C than cold storage with a difference of 17.56%. Ozone treatment of 0.1 ppm in room temperature storage had higher levels of vitamin C than cold storage with a difference of 14.70%.

IV. DISCUSSION

The vitamin C content of strawberries before storage was 927.13 mg/100g. During the storage process, almost all treatments experienced an increase in vitamin C content, but in the 0.08 ppm ozone treatment, cold storage decreased. The increase in vitamin C content occurs because the strawberries undergo a ripening process to an optimal level. The fruit changes both color, taste, and texture changes. In this ripening process, strawberries experience an increase in the amount of simple sugar content [11]

The increase in vitamin C content in the 0 ppm ozone treatment could be due to the biosynthesis of vitamin C from glucose found in fruit [12]. Vitamin C is a secondary metabolite formed from glucose via the D-gluconic acid and L-gluonic acid pathways. The formation of vitamin C occurs due to the presence of glucose 6-PO4 substrate due to the withering phase that occurs. The temperature of the fruit storage area affects the stability of vitamin C. The lower the temperature of the fruit storage environment, the more stable vitamin C usually is. Shelf life also affects the content of vitamin C, the longer the shelf life of fruit, usually the content of vitamin C continues to increase. If the substrate for vitamin C is not available, then vitamin C will decrease and increase [13]. Ozone treatment at 10°C had a higher vitamin C content because its shelf life was longer than at 27°C. all ozone treatments stored at 10°C have a longer shelf life than storage at 27°C.

The increase in vitamin C that occurred in the ozone treatment was due to ozone being able to inhibit the performance of the ascorbate peroxidase enzyme or ascorbate oxidation. Ascorbate peroxidase enzyme or ascorbate oxidation plays a role in the oxidation process of vitamin C so that if the enzyme's performance is inhibited, the vitamin C oxidation process decreases, and the vitamin C content increases [14]. In addition to ozone treatment, the temperature of the strawberry fruit storage area also affects the activity of the ascorbate peroxidase enzyme or ascorbate oxidation. Storage at 10°C was able to suppress enzyme activity and suppress the oxidation of ozone to oxygen.

The decrease in vitamin C in the 0.08 ppm ozone treatment in cold storage could be due to the oxidation process of vitamin C. There are 2 kinds of vitamin C oxidation, namely spontaneous oxidation due to reaction with ambient air and non-spontaneous oxidation due to catalytic enzymes. The mechanism of spontaneous oxidation is that oxygen will attack the ascorbic acid monoanion[to produce ascorbate anion radicals and H2O followed by the formation of ascorbic acid dehydro and hydrogen peroxide. Dehydroascorbic acid (L-dehydroascorbic acid) is an oxidized form of L-ascorbic acid which is part of vitamin C. L-ascorbic acid is very labile and can turn into 2.3-Ldiketogulonic acid (DKG) which has no active vitamin C properties. If DKG has been formed, then vitamin C will decrease and even eliminate vitamin C content in horticultural products [15].

V. CONCLUSION

Ozone can maintain and increase vitamin C levels during storage. The best treatment that can maintain and increase the content of vitamin C during storage is ozone treatment of 0.05 ppm at 10°C storage temperature with final content of vitamin C as much as 1350.03 mg/100g

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