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Effect Of Difference In The Number Of Fruit Arrangements On The Level Of Mechanical Damage And Quality Of Strawberries (*Fragaria Sp*.) Cultivars Shed During The Storage Period

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Abstract. This study seeks to assess the impact of varying quantities of fruit arrangements in packaging on the extent of mechanical damage and the quality of strawberry (Fragaria sp.) cultivars during the storage duration. The study was conducted in the Product Processing Technology Laboratory, Faculty of Agriculture, Gunung Jati Independent University, Cirebon, from May 2024 to June 2024. The research employed an experimental procedure utilizing a Complete Random Design (RAL) with three treatment levels (1-layer fruit arrangement, 2-layer fruit arrangement, and 3-layer fruit arrangement), replicated nine times, resulting in 27 experimental units (27 packages). The observed factors were mechanical damage, weight loss, fruit hardness, total dissolved solids, and vitamin C content. The data were evaluated using the F test at a 5% significance level, and if a significant effect was observed, the Scott Knott test was subsequently applied at the same error level. The results indicated that the variation in the quantity of fruit arrays within the package influenced fruit weight loss, total dissolved solids, and vitamin C content in strawberries (Fragaria sp.). The optimal configuration of strawberries, considering mechanical damage, weight loss, fruit hardness, total dissolved solids, and vitamin C content, is a two-layer arrangement.

Keywords: Strawberries, Fruit Composition, Mechanical Damage, Quality

INTRODUCTION

The strawberry is a fruit recognized for its high vitamin C content. Strawberries are not only abundant in vitamin C but also provide vitamins B5, B6, K, manganese, folic acid, potassium, riboflavin, copper, magnesium, and omega-3 fatty acids. Besides being eaten as fresh fruits, strawberries are extensively utilized in processed forms, including jams, confections, syrups, dodol, yogurt, and as ingredients in cakes and ice cream. Moreover, strawberry fruit is abundant in anthocyanins and ellagic acid, which serve as antioxidant molecules capable of neutralizing oxidants in the human body (Rohmayati M, 2013).

Strawberries include phytochemical substances, specifically ellagic acid, a phenolic compound with putative anticarcinogenic and antimutagenic properties, as well as benefits for skin enhancement, teeth whitening, bad breath elimination, and improvements in cognitive function and vision. These phytochemical substances can enhance immunity and serve as antiviral agents. Francesca, 2012.

Strawberries are perishable goods, indicating that they are susceptible to harm. Another property of strawberries is their climatic qualities, which indicate that post-harvest, they readily experience alterations in physical and chemical properties due to ongoing metabolic activity. Alterations in physical and chemical properties may result from mechanical, physical, microbiological, and physiological damage. Climacteric fruits require a ripening period before consumption. The quality of fruit storage is intricately linked to the processes of respiration and transpiration during handling and storage. (Cortesa, 2015)

Strawberries are prone to mechanical injury, texture degradation, physiological abnormalities, and pathogen infections, resulting in a significant degree of perishability (Kalifa et al., 2016). This occurs because the fruit remains metabolically active during storage (Jianglian and Shaoying, 2013).

The process of optimizing extra fruit packing by horticultural businesses, farmers, and wholesale traders tries to enhance the efficiency of containers and align with consumer market demand. Excessive packaging or excessive accumulation during the preparation of fruits and vegetables exerts significant pressure on the bottom layer of fruit, thereby heightening mechanical damage due to pressure, compression, and vibration occurring during transportation and storage (Cortesa et al., 2015).

Based on the background of the research mentioned above and there is not much information about the technique of arranging strawberries in packaging, especially the number of strawberry arrangements that can minimize mechanical damage, it is necessary to conduct a study entitled

"The Effect of Differences in the Number of Fruit Arrangements on the Level of Mechanical Damage and Quality of Strawberries (*Fragaria Sp.*) cultivars shed during the storage period".

This study aims to determine the effect of the difference in the number of fruit arrangements in the package on the level of mechanical damage and the quality of strawberries (*Fragaria sp.*) cultivars during the storage period

LITERATURE

Strawberries are perishable goods, indicating that they are susceptible to harm. Another property of strawberries is their climatic qualities, which indicate that post-harvest, they readily experience alterations in physical and chemical properties due to ongoing metabolic activity. Alterations in physical and chemical properties may result from mechanical, physical, microbiological, and physiological damage. Climacteric fruits require a maturation period before consumption. The quality of fruit storage is intricately linked to the processes of respiration and transpiration during handling and storage. (Cortesa, 2015)

Strawberries can suffer mechanical damage during the packaging, transportation and post-harvest storage process, the damage is caused by enzymatic reactions, chemical reactions and microbial activity. Some of the pathogenic fungi found on strawberries include *Botrytis cinerea* (gray spot), *Collectrichum acutatum* (rot on fruit), and *Phytophthora cactorum* (damage to fruit skin) (Falah *et al.*, 2018).

Mechanical damage can be caused by collisions and friction between strawberries and between strawberries and the packaging as well as due to pressure and overload in the packaging. Visually, the consequences caused by mechanical damage to the fruit include *Browning* (Browning), there are parts of the fruit that are blistered, peeled, bruised, which causes the commodity to wither and rot. The impact of mechanical damage causes fruits to not have a shelf life or a long shelf life (Amalia *et al.*, 2018). According to Nasution (2013), strawberries are prone to mechanical damage due to high water content, while the impact that occurs due to mechanical damage to strawberries is microbial growth, increased respiration rate and transpiration rate and shrinkage of fruit mass.

Mechanical damage to strawberries can result in a reduction of fruit bulk, an increase in respiration rate, and elevated transpiration rate. Excessive transpiration will result in weight loss, diminished aesthetic appeal (due to wilting), reduced textural quality (hardness), lower glucose levels, and decreased vitamin C content (Nasution, 2013).

METHOD

This experiment was carried out at the Laboratory of Product Processing Technology, Faculty of Agriculture, Gunung Jati Independent University, Cirebon from May 2024 to June 2024.

The materials used in this study are iodine 0.1 N, 1% amylum, aquades and strawberries of *the Mencir* variety obtained from the Strawberry Farm of the Business Incubator "BBPP LEMBANG" Jalan Kayu Ambon No.82 Lembang West Bandung, West Java. The strawberries used as samples in this study are strawberries harvested from strawberry plants that are healthy, free of pests and diseases, have normal growth with a uniform level of lushness (homogeneous). The maturity level of the harvested fruit is at a maturity index of 90% (25 days after the flowers bloom) with the characteristics of reddish-yellow fruit skin. Other criteria are that strawberries have the same size and shape, are smooth without mechanical damage, free of pests and diseases, have a stalk of at least 0.5 cm and the petals are still intact and fresh. The weight of strawberries that will be used as a sample in this study is second-class quality strawberries with a weight of 12-15 grams per grain.

The tools used are scissors, calipers, mica plastic packaging measuring 14.5 cm x 10.5 cm x 9 cm, 14.5 cm x 10.5 cm x 7 cm, 14.5 cm x 10.5 cm x 5 cm, digital scales, tissues, perforated plastic harvest baskets, mobile phone cameras, labels, pipettes, beker glasses, markers, washcloths, knives, measuring cups, *thermohygrometers, hand refractometer atago PR-201, fruit hardnestmeter/penetrometer,* Erlenmeyer glass, buret, static, funnel, stirrer, bunsen, tripod, gauze wire, mortar and pestle (pestle).

This study uses an experimental method with a Complete Random Design (RAL). The treatment is various number of fruit arrangements, which consists of 3 (three) treatments, namely:

S1 : Fruit Arrangement 1 Layer

S2 : 2-Layer Fruit Arrangement

S3 : 3-Layer Fruit Arrangement

Each level of treatment was repeated 9 (nine) times until there were a total of 27 experimental units (27 packages)

Observations were made on the level of mechanical damage (%), weight loss (%), fruit hardness (kg/cm2), vitamin C (mg/100g), and total dissolved solids (TPT) ($^{oBrix).}$

Fruit Mechanical Damage Rate (%)

The assessment of mechanical damage to strawberries is conducted visually by identifying the types of mechanical injuries present. specifically contusions, abrasions, and lacerations (exfoliation). All fruits, regardless of size, that sustained damage in this study are classified as having had mechanical injury.

The limits used to determine whether strawberries have bruises, scratches, and broken wounds (peeling) are as follows:

a. Bruises

Strawberries are deemed bruised if there is a discoloration to a darker hue or the emergence of dark spots that deviate from the natural skin of the fruit. This region has a slight softness relative to other areas of the skin. Bruises resulted from pressure within the storage diving container.

b. Scratches

Scratches on the outer skin of strawberries are viewed as wounds, leading to the deterioration of the protective tissue. Scratches arise from friction between materials and other objects or packaging materials.

c. Broken Wounds

The strawberry fruit is classified as a ruptured wound as it opens, revealing the flesh tissue behind the skin. Fractures may occur if there is a tear or rupture of the strawberry's epidermis. Fracture wounds arise from pressure within the packing and result in shocks during shipment.

This observation was carried out on day 4 by comparing the number of strawberries that experienced mechanical damage to the number of strawberries in each treatment. The equation used to calculate the mechanical damage that occurs is as follows: (Asgaf, 2017).

$$\% \text{ KM} = \frac{JSR}{TBS} \text{X } 100\%$$

Information:

KM = Mechanical Damage (%)

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JSR = Number of Spoiled Strawberries on day 4

FFB = Total Strawberries

Fruit Weight Loss (%)

The assessment of fruit weight loss is the percentage variation between the original weight of strawberries and their ultimate weight post-storage. Weight loss measurements were conducted on all strawberries packaged with a digital scale. The percentage of material weight reduction from the commencement to the conclusion of storage determines weight loss assessments. The weight loss measurement was conducted on two occasions in this study. The initial weighing occurs on the day of harvest, while the subsequent weighing takes place on the fourth-day post-harvest. A formula is employed to determine weight loss, as stated by Winarso (2019):

$$\text{Weight loss (\%)} = \frac{A - B \times 100\%}{A}$$

Information:
A = Initial fruit weight (gr)
B = Final fruit weight (gr)

Fruit Hardness (Kg/cm2)

The hardness of strawberries was assessed using a penetrometer, which evaluated the fruit's resistance to penetration. Measurements of strawberries were conducted by affixing a penetrometer to the middle of the fruit, ensuring the penetrometer was perpendicular to the strawberry's surface. The fruit's hardness is denoted by the reading on the penetrometer. The operational premise of a penetrometer is to quantify the penetration depth of the penetrometer needle under a certain load weight over a designated time (mm/g/s). The unit of measurement of fruit hardness is expressed in kg and the compressive strength value is expressed in kg/cm2 (Nasrudin, 2019). Observations are conducted on the fourth day post-harvest. The strawberries utilized amounted to 2 permica, and the sample was extracted from the lower section of the package.

Vitamin C content (mg/100 g)

The quantification of vitamin C was conducted utilizing the titration method with a 0.01 N iodine solution. The first stage involves slicing strawberries into small segments weighing 1-2 grams each, followed by mashing the strawberry segments. The pulverized material is placed in a beaker, followed by the addition of distilled water to a total volume of 100 ml. Fifteen milliliters of filtrate were transferred into an Erlenmeyer flask and treated with two milliliters of amylum indicator, followed by titration with a 0.01 N standard iodine solution until a blue color was observed (Ngginak et al, 2019) which was calculated by the formula:

$$\text{Vitamin C Level } (/g) = \frac{(\text{vol I,x } 0.88 \text{ x Fp x } 100)}{\text{Sample W } (g)}$$

Information:
Vol I2 = Volume of iodine (mL)
0.88 = 0.88 mg Vitamin C equivalent to 1 mL of I2 solution
0.01 N Fp = Dilution factor
Ws = Sample weight

Observations are carried out on the fourth day after harvest. The fruit used is one permit, with three titrations.

Total dissolved solids (TPT) (Brix)

Total dissolved solids are quantified via a handheld refractometer. Measurements were obtained by extracting the flesh from the center of the strawberries. The TPT value is determined by mashing strawberries and applying the juice onto the glass surface of the refractometer, allowing the TPT value to be shown directly on the device's screen in oBrix units (Lestari et al., 2017). Observations occur on the fourth-day post-harvest. The number of strawberries utilized was equivalent to 2 permits.

DISCUSSION

Fruit Mechanical Damage Rate

The results of statistical analysis showed that the difference in the number of strawberry arrays had a real effect on the level of mechanical damage of strawberries. The S3 treatment (3-layer fruit arrangement) was significantly different from the S2 treatment (2-layer fruit arrangement) and the S1 treatment (1-layer fruit arrangement). Based on Table 1, it shows that the highest level of mechanical damage is in the S3 treatment and the lowest in the S1 treatment. This is because in the S3 treatment with a 3-layer fruit arrangement, strawberries in the third layer, many experienced mechanical damage due to greater pressure compared to the S1 and S2 treatments.

Table 1. Effect of Difference in Number of Fruit Arrangements on the Level of Mechanical Damage of Strawberry Fruits (%)

It	Treatment	Fruit Mechanical Damage Rate (%)
1	S1	15.29 A
2	S2	16.42 A
3	S3	23.17 b

Caption: The average number accompanied by the same letter in the column shows an insignificant difference according to the Scott Knott Cluster Test at the 5% level.

Mechanical damage can be caused by collisions and friction between strawberries and between strawberries and the packaging as well as due to pressure and overload in the packaging. The browning process characterizes the mechanical damage due to abrasions, scratches, peeling, and bruises due to impact and pressure on the fruit, which will trigger an increase in the rate of respiration, transpiration, and ethylene production, which can accelerate the wilting and decay process. (Cortesa, *et al.,* 2015)

According to Sabir and Farooquie (2015), mechanical damage occurs to strawberries due to the number of fruit arrays in the package is too large, causing strawberries located at the very bottom of the package to cause the surface of the strawberry skin to be injured and bruised, due to excessive pressure,

The results of Rahayu's (2012) research showed that red chili fruits stacked in 5 layers on carton box packaging measuring 30 cm x 20 cm x 20 produced the highest level of mechanical damage compared to red chili fruits stacked in 4, 3, and 1 layers.

Mechanical damage is seen in the abrasions, scratches, and bruises on the chili. Excessive build-up in the packaging can cause great stress on the bottom layer, increasing mechanical damage. The results of Zelzha Arinnesia Varanita's research (2016) showed that the highest percentage of mechanical damage occurred in tomatoes in packaging boxes with 4-layer stacks. In the treatment of 4-layer piles, mechanical damage reaches 35%.

Weight Loss

The weight of strawberries is a key quality measure for fresh strawberries. The reduction in weight of fruits is attributed to the loss of carbon during respiration. During respiration, the carbon molecules in fruit sugar react with oxygen, resulting in the formation of simple volatile compounds, specifically carbon dioxide and water vapor, leading to a reduction in the fruit's weight (Arisanta and Handriatni, 2020).

Table 2. Effect of Difference in Number of Fruit Arrangements on Strawberry Weight Loss (%)
Caption: The average number accompanied by the same letter in the column shows an insignificant difference according to the Scott Knott Cluster Test at the 5% level.

It	Treatment	Strawberry Fruit Weight Loss (%)
1	S1	2.21 A
2	S2	5.14 b
3	S3	8.62 c

The statistical analysis results showed that the treatment of the difference in the number of fruit arrangements in strawberries had a significant effect on the weight loss of strawberries. Table 2 shows that the more layers of strawberry arrangement, the higher the weight loss of strawberries. The S3 treatment (3-layer fruit arrangement) was different from the S2 treatment (2-layer fruit arrangement) and the S1 treatment (1-layer fruit arrangement) and showed the highest fruit weight loss value (8.62%) compared to other treatments (S2 and S3). This is suspected because the metabolic process is faster in the S3 treatment (3-layer fruit arrangement) than in the S2 and S1 treatments. The process of fruit metabolism during storage includes respiration and transpiration. Strawberries will experience greater weight loss under conditions of high respiratory rate. The reduction in strawberry weight results from diminished water content and the respiration process that transforms the substrate into CO2 and H2O. During storage, fruit undergoes continuous weight loss due to water loss from respiration and transpiration, which can lead to deterioration and diminished quality as a result of increased temperature within the packaging from energy release (Sudjatha & Wayan, 2017).

Hardness

The hardness of strawberries is a parameter used to determine the quality of strawberries. One of the processes that occurs during storage after the fruit is harvested is the softening of the hardness of the fruit. Strawberry hardness is measured with a penetrometer with a needle diameter of 1 cm (Rahmadani et al., 2021). Elevated respiration rates can expedite the weakening of strawberry flesh. Strawberries are vulnerable to impacts during transit and the manufacturing process. Additional factors influencing the texture of strawberries encompass microbiological damage, mechanical damage, and physiological damage (Muchtadi & Sugiono, 2013)

Table 3. Effect of Difference in Number of Fruit Arrangements on Strawberry Hardness (kg/cm2)
Caption: The average number accompanied by the same letter in the column shows an insignificant difference according to the Scott Knott Cluster Test at the 5% level.

It	Treatment	Strawberry Fruit Hardness (%)
1	S1	1.34 A
2	S2	1,27 A
3	S3	1.25 A

Based on the statistical analysis results, it was shown that the treatment of the difference in the number of fruit arrangements had no real effect on the hardness of strawberries. However, the S1 treatment (1-layer fruit arrangement) showed a greater value of violence than other treatments. This is also due to the S1 treatment (1-layer fruit arrangement) metabolic and respiration processes during storage are slower than other treatments (2-layer fruit arrangement treatment and 3-layer fruit arrangement).

The hardness of the fruit is influenced by its respiration rate; as the quantity or arrangement of fruit in the packaging increases, so does the effect. Elevate air temperature and ethylene concentration in the packing to induce an increase in the respiratory rate. The fruit's hardness will diminish due to the destruction of cell wall constituents, particularly pectin, by pectolytic enzymes, leading to tissue senescence and subsequent cell wall damage from the respiration process (Rahmadani et al., 2021).

The respiration process involves the catabolism of carbohydrates into simpler chemicals, leading to the degradation of tissue in the fruit, resulting in its softening. Simultaneously, during the transpiration process, water evaporation transpires, leading to the wilting and shrinkage of the fruit, resulting in a softened texture (Syafutri et al., 2006).

The storage process of strawberries involves a transformation of the chemicals present in the fruit. The reduction in the fruit's hardness value results from the transformation of insoluble protopectin into soluble pectin and pectic acid, which dissolve in water, leading to the softening of the fruit (Kusumiyati et al., 2019). The reduction in the fruit's hardness during respiration is attributed to turgor loss, the conversion of starch into sugar, and the destruction of cell walls. The occurrence of turgor alterations is attributed to modifications in the cell wall composition, which influence the firmness of the fruit and will persist in softening during the storage period. Prolonged storage duration results in a diminished hardness value. This occurs due to a link between the fruit's texture and respiration. Increased respiration results in greater water loss in fruit, leading to lower cell turgor and subsequent softening of the cells (Sari et al., 2015).

Total Dissolved Solids (TPT)

A criterion of fruit ripening is the elevated sweetness content in the fruit. Total Dissolved Solids (TDS) include all solids dissolved in fruit, including sugars, vitamins, and other constituents. The primary soluble component in fruit is sugar. Hence, the TPT quantity reflects the fruit's total sugar content as determined (Yulianti et al., 2016).

Table 4. Effect of Difference in Number of Fruit Arrangements on Total Dissolved Solids (TPT) Strawberries (^{o} Brix$^{)}$

It	Treatment	Total Dissolved Solids (TPT) Strawberry Fruit (^{o} Brix)
1	S1	9,11 A
2	S2	9.52 b
3	S3	10.62 c

Caption: The average number accompanied by the same letter in the column shows an insignificant difference according to the Scott Knott Cluster Test at the 5% level.

Based on the results of statistical analysis, it was shown that the difference in the number of strawberry fruit arrays had a real effect on the total dissolved solids of strawberries. The S3 treatment (3-layer fruit arrangement) was significantly different from the S2 treatment (2-layer fruit arrangement) and the S1 treatment (1-layer fruit arrangement). Based on Table 4, it shows that there is an increase in TPT value in strawberries, the highest TPT value is in the S3 treatment and the lowest in the S1 treatment. This is suspected because in the S3 treatment with a 3-layer fruit arrangement, strawberries experience faster breakdown of carbohydrates into sugar. Strawberries that are stored in S1 treatment packaging, the starch reshuffle process is still running slowly, therefore the TPT content is not too much. Strawberries contain a lot of carbohydrates in the form of starch and during the ripening process these contents will turn into sugars (sucrose, fructose, and glucose) (Putri et al., 2015).

Novaliana (2008) states that total dissolved solids reflect the overall sugar content in the fruit. Storage will result in alterations to the starch content and simple sugars. The rise in total dissolved solids in the fruit during storage results from the conversion of starch into simple sugars, whereas the decline in total dissolved solids occurs due to the utilization of sugar as a substrate for respiration to generate energy.

Vitamin C

Based on the results of statistical analysis, it shows that the difference in the number of fruit arrangements has a real effect on the vitamin C content of strawberries. Table 5 shows that there is a difference in vitamin C content in strawberries, the S1 treatment (1-layer fruit arrangement) is significantly different from the S2 treatment (2-layer fruit arrangement) and the S3 treatment (3-layer fruit arrangement). The highest vitamin C content was in the S1 treatment (1-layer fruit arrangement). The more layers the strawberry fruit arrangement during the storage period, the lower the Vitamin C content of the strawberry fruit.

Table 5. Effect of Differences in the Number of Fruit Arrangements on Fruit Vitamin C Content Strawberries (mg/100 g)

It	Treatment	Vitamin C Content of Strawberry Fruit (mg/100 g)
1	S1	55.63 c
2	S2	44.51 b
3	S3	22,93 A

Caption: The average number accompanied by the same letter in the column shows an insignificant difference according to the Scott Knott Cluster Test at the 5% level.

Vitamin C or ascorbic acid is commonly found in fruits and vegetables. Vitamin C in the storage process is easily soluble in water and easily damaged by oxidation, heat, and alkali (Asmara dan Amungkasi, 2019)The more fruit in a container, the higher the temperature will be due to the release of energy. This will cause the amount of ethylene gas in the package to increase faster, triggering an increase in the fruit's respiration process. The respiration process of strawberries results in the loss of nutrients contained in the fruit, including vitamin C.

The reduction in vitamin C levels is attributable to respiratory processes that persist after storage. The respiration process can elevate the metabolic rate, resulting in the oxidation of vitamin C and a subsequent reduction in its levels (Buhari, 2010). Vitamin C is typically destroyed or compromised by oxidative reactions. This process is activated by light, oxygen, heat, peroxide, and enzymes, such as ascorbate peroxidase or peroxidase (Muchtadi et al., 2013).

CONCLUSION

The variation in the quantity of fruit stacks within the package significantly influenced mechanical damage, fruit weight loss, fruit hardness, total dissolved solids, and vitamin C content in strawberries (Fragaria sp.). The optimal strawberry arrangement, considering mechanical damage, weight loss, total dissolved solids, and vitamin C content, is a 2-layer configuration.

BIBLIOGRAPHY

Amalia, R. R., Hairiyah, N., & Nuryati. (2017). Mapping of the Fruit Supply Chain of Tanah Laut Regency. In National Seminar on Applied Research 2 (p. E25). Banjarmasin: Banjarmasin State Polytechnic

Arisanta., and Handriatni (2020). Effect of Salicylic Acid Concentration and Packaging Type on the Shelf Life of Bulu Plantain Bananas (Musa paradisiaca (L) var. Sapientum). Agricultural Scientific Journal. Vol. 16, No. 1

Asgaf, A. (2017). Effect of Storage Temperature and Number of Packaging Perforations on Physical and Chemical Characteristics of Broccoli (Brassica oleracea Var. Royal G) Fresh-Cut. Journal of Horticulture, 27(1), 127–136.

Asmara, A.P., Amungkasi, H.K. 2019. Kinetic Study of the Effect of Storage Duration on Vitamin C Levels in Malang Apples (Malus sylvestris). Al-Chemistry, 7(2), 136–146

Buhari, I., (2010), Analysis of Vitamin C Levels in Salak Fruit Processed Products (Salacca zalacca) by UV-Vis Spectrophotometry, Thesis, Faculty of Health Sciences, Alauddin State Islamic University.

Cortésa, V., Ortiz, C., Aleixos, N., Blasco, J., Cubero, S., & Talens, P. (2015). A new internal quality index for mango and its prediction by external visible and near-infrared reflection spectroscopy. Postharvest Biology and Technology, 118, 148–158. https://doi.org/10.1016/j.postharvbio.04.2016

Falah, M.A.F., Yuliastuti, P., Hanifah, R., Saroyo, P. and Jumeri (2018). The quality of strawberries (Fragaria sp cv Holibert) is fresh and stored in a tropical environment from the Ketep plantation in Magelang, Central Java. Journal of Agroindustry 8(1): 1–10

Francesca, G. D. 2012. The Strawberry : Composition, Nutritional Qualilty and Impact on Human Health. Elsevier, USA

Helmiyesi, Hastuti, R. B., Prihastanti, E., 2008. Effect of storage time on sugar and vitamin C levels in Siamese citrus fruit (Citrus nobilis var. microcarpa). Bulletin of Anatomy and Physiology Volume XVI, Number 2, 2008

Jianglian. D, and Z. Shaoying. 2013. Application of chitosan based coating in fruit and vegetable preservation: A review. J Food Process Technol. Vol 4: 227. Issue 5.ISSN 2157-7110.p.1-4. doi: 10.4172/2157-7110.1000227

Khalifa I, Barakat H, El-Mansy HA and Soliman AS. 2016. Effect of Chitosan- Olive Oil Processing Residues Coatings On keeping Quality Of Cold Storage Strawberry (Fragaria ananassa var. Festival). Jounal of Food Quality. ISSN 1745-4557. p.504-515. http://doi.org/10.1111/jfg.12213.

Kusumiyati, et al. 2018. Effect of Storage Time on the Total Value of Dissolved, Hardness and Weight Shrinkage of Arumanis Mangosteen Fruit. Cultivation Journal. 3: 766-771.

Lestari, R., Hasbullah, R., & Harahap, I. 2017. Vapor Heat Treatment and Storage Temperature for Maintaining Quality of Arumanis Mango (Mangifera indica L.). Journal of Agricultural Engineering, 05(2),1–13. https://doi.org/10.19028/jtep.05.2.177-184

Muchtadi, T. R., and Sugiyono. 2013. Principles and Processes of Food Technology. Alfabeta, Bogor

Nasution, R. P. Trisnowati, S., and Putra, E. T. S. 2013. Effect of prolonged ultraviolet-c irradiation and packaging method on the quality of strawberries (Fragaria x ananassa Duchesne) during storage. Vegetalika 2(2): 87-99

Nasrudin. (2019). Study of the Impact of La Nina on the Quality of Salak Pondoh (Salacca Edulis Reinw.) During room temperature storage. Journal of Tropical Galung. Vol.8(2):103-111

Ngginak, J., Dian, A., Rupidara, N., Daud, Y., & Ntt, K. 2019. Vitamin C Content from Fig Fruit Extract (Ficus carica L .) and Forest Passion Fruit (Passiflora foetida L .). 2(2), 54–59.

Novaliana, N. 2008. Effect of Coating and Storage Temperature on the Quality and Shelf Life of Pineapple (Ananas comosus L Merr). Thesis of the Department of Agronomy and Horticulture, Bogor Agricultural University. Bogor

Rahayu 2012. Analysis of the Quality and Level of Mechanical Damage of Red Peppers During the Shipping Process from the Production Farm to the Packaging Warehouse. Research Report. Cimanggu Postharvest Center. Bogor

Rahmadani, P. D., Budiman, Daryanto, A., & Widiyanto, S. (2021). Evaluation of Characteristics and Characteristics of Tomato Plant Yield Components (Solanum lycopersicum L.) Generation F6 in Lowland Greenhouse. Journal of Precision Agriculture, 5(2), 95–108.

Rohmayati, M. 2013. Strawberry Cultivation in Narrow Land. Infra Pustaka. Bandung

Sabir, L. B., & Farooquie, J. A. (2015). Managing fruits and vegetables inventory: A study of retail stores. South Asian Journal of Marketing & Management Research, 5(8), 47–60.

Sari, R. N., Novita, D. D., & Sugianti, C. (2015). Effect of Carrageenan Flour and Glycerol Concentration as Edible Coating on Changes in Strawberry Fruit Quality (Fragaria x ananassa) during Storage. Journal of Lampung Agricultural Engineering, 4(4), 305–314.

Shamaila, M., Powrie, W. D., and Skura, B. J. 1992. Sensory evaluation of strawberry fruit stored under modified atmosphere packaging (MAP) by quantitative descriptive analysis. Journal of Food Science 1168-1184

Sudjatha, W., and Wisaniyasa, N. W. (2017). Postharvest Physiology and Technology (Fruits and Vegetables). Textbooks. Udayana University Press: Bali

Putri, T. K., D. Veronika., A. Ismail., A. Karuniawan., Y. Maxiselly., A. W. Irwan and W. Sutari. 2015. Utilization of local banana types (banana and plantain) in West Java based on sale and flour products. A. Cultivation. 14(2): 63-70

Winarso, W. D. 2019. Evaluation of Post-Harvest Maturity of Goods Bananas to *Determine the Best Harvest Time Based on the Accumulation of Heat Units* Wijoyo, P.M. 2008. Secrets of Strawberry Cultivation and Economy. Bee Media Indonesia. Jakarta

Yulianti, L. E., Hasbullah, R., & Purwanti, N. 2016. Effect of Hot Water Treatment on the Quality of Guava Fruit (Psidium guajava L.) During storage. Journal of Agricultural Engineering, 4(2), 171–178. https://doi.org/DOI: 10.19028/jtep.04.2.171-17

Zelzha Arinnesia Varanita, Tamrin, and Agus Haryanto. 2016. Effect of Vibration on Mechanical Damage of Tomatoes (Lycopersicum esculentum Mill). Journal of Lampung Agricultural EngineeringVol.5, No. 2: 117-124