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Postharvest Quality and Physicochemical Analysis of Strawberry (*Fragaria ananassa* L.) to Various Application of Mulching and Organic Fertilizers

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ABSTRACT

Background: In reducing postharvest losses, maintaining the quality of fruits can preserve nutrient content that earns higher prices in the market of fresh produce perishables. Strawberry as one of the economically important crops has led to increased production with high demand in many regions around the world. Maintaining the postharvest quality of this crop greatly influenced shelf-life and market demand, therefore, this study investigated the influence of various mulching methods and organic fertilizer particularly on the postharvest quality aspects and physicochemical analysis of strawberries.

Methods: A study was conducted to determine the type of mulching methods (rice hull and plastic mulch) and organic fertilizers (vermicast, vermicompost and vermitea) used to enhance the postharvest quality of strawberries. Harvested fruits were carefully selected at commercial maturity stage and subjected to shelf-life evaluation and physicochemical analysis for 7 days of storage. It was carried out in a completely randomized design (CRD) with ten sample fruits per treatment replicated three times.

Result: Among the data parameters evaluated, strawberry fruits harvested under plastic mulch condition applied with vermicompost, vermicast and vermitea significantly produced great results in terms of improving the postharvest quality parameters evaluated particularly on the general acceptability, visual quality rating, firmness and shriveling index. On the other hand, comparable results were also observed among the physicochemical analysis of harvested fruits from all the treatments particularly on the total soluble solids (TSS) and titratable acidity (TA). The results revealed that strawberries under plastic mulch applied with organic fertilizers (vermicompost, vermicast and vermitea) enhanced postharvest quality and increased shelf-life of harvested strawberry fruits.

Key words: Mulching, Organic fertilizers, Physicochemical analysis, Postharvest quality, Strawberry.

INTRODUCTION

Strawberry, *Fragaria ananassa* is known as the most well-known non-climacteric fruits that belong to the Rosaceae family. This perishable fruit has lot of nutritional and organoleptic characteristics that are commercially acceptable, so it grown to eat that as fresh, processed, beverage or preserved (Nasrin *et al.,* 2017a). This fruit contains high content of flavonoids (dihydrochalcones (phloridzin), epicatechin, catechin, proanthocyanidin B1 and flavonols (quercetin derivatives) (Giampieri *et al.,* 2012; Hilt *et al.,* 2003). Novel flavonol biosynthesized called Fisetin in the strawberry fruit plays an important major role that improved anticancer and antioxidant activity (Syed Deeba *et al.,* 2013). It also contains significant content of hydrolysable tannins (gallotannins and ellagitannins) with an estimated content ranges from 8-23 mg per 100 fresh weight strawberry fruit (Buendia *et al.,* 2010).

Being a non-climacteric fruit, a strawberry attains its highest quality features like firmness, glossiness, normal size, regular shape, sweet taste, full red color and aroma when fruits fully ripe when still attached to the plant, before harvest (Parves *et al.,* 2018). Marketable strawberry fruits have a healthy stem and calyx, however, at this stage, they need more delicate, skillful and careful harvesting method due to very thin pericarp (Hayashi *et al.,* 2010). Strawberries with e≥75% red color development are preferably picked to withstand rigors of transport. The firmer fruits are intended for distant or export markets. Even though fruits are already harvested, taste can no longer be improved fruits softening and color development to full red. The strawberry fruits are harvested in the cooler part of the day; generally, in morning hours, when the pulp temperature does not exceed 25°C and fruits are not wet.

Poor harvesting methods and undesirable time of harvest will cause decay incidence, shriveling and bruising to the strawberry fruits, to avoid that, precooling is necessary. Too large and over mature or ripe berries fetch a low market due to low characteristic value. Several studies on

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intelligent robotic and mechanical harvesting methods of strawberries were reported, which are mostly used in hydroponic systems and high-tech protected cultivation units.

The quality of strawberry fruit is influenced by improper cultural management. Mulching significantly influenced the quality of strawberries produced. The application of mulching is practice which helps proper development and growth of the plants by modifying the temperature of the soil, better moisture conservation and adequate nutrient availability (Shukla *et al.,* 2021). In addition, Sharma and Sharma (2004) reported that mulching has a significant impact on the yield, quality and duration of the harvesting that improves modification in soil temperature, soil moisture conservation, control weeds and enhanced nutritional value. Moreover, organic farming not only enhances growth and yield performance but also can enhance soil biodiversity and improve food safety (Kumar *et al.,* 2023).

Several research have been conducted as to the influence on the postharvest quality of perishables applied with various organic fertilizer particularly on the aspect of agricultural yield production. It is common that chemical fertilizers are generally used to significantly increase yield, but at high environmental cost and production have led to the use of organic fertilizers considered as an alternative to synthetic farm inputs. Many characteristics of several studies as to the use of organic fertilizers have been scientifically proven consisting mostly of waste. Scientific literature on increasing the yield with the used of organic fertilizers includes chicken manure and vermicompost in beans (Upenji *et al.,* 2020), tomatoes (Sönmez *et al.,* 2019; Wang *et al.,* 2017), lettuce and strawberry (Kilic *et al.,* 2019; Negi *et al.,* 2021) were reported.

With several past studies, this investigation was carried out with an objectives that aimed to evaluate the postharvest quality and physicochemical analysis of strawberry (Variety: Shoga) as influenced by mulching (ricehull and plastic mulch) and organic fertilizers (vermitea, vermicompost and vermicast).

MATERIALS AND METHODS

Source of fruits and site of field experimental area

The site of harvested fruits used in the study was located at Sitio Sayaban, Barangay Ilovamis, Kidapawan City Philippines (Latitude: 6.735009; Longitude: 124.818287) from December 2015-March 2016. The area has an elevation of 756.5 meters above sea level.

Field experimental set-up

Mulching materials were applied three days before transplanting strawberry runners. A total of 10 sample plants with a plot size of 0.5 × 3 m. Mulching materials/treatment used in the experiment are as follows: without mulching (control); plastic mulch and rice hulls. Organic fertilizers applied in strawberry under various mulching materials were vermicompost and vermicast using localized placement application (100 g/ plant) and vermitea through drenching application technique at 50 ml/plant. Inorganic fertilizer (10 g/plant) was also applied as commercial standard check. The application of all treatments was done every 15 days from the start up to the termination of the study (3 months duration).

Harvesting and selection of strawberry fruits

Strawberry fruits were carefully harvested based on the different treatments of the experiment (mulching materials and organic fertilizers) following the criteria for commercial stage of maturity: 2/3rd maturity stage (fruit surface turns pink to red color at 25-28 days after anthesis).

Harvested fruits were collected from experimental plots applied with various treatment combinations evaluated were as follows (a. nm + control (without fertilizer application); b. nm+ vermitea; c. nm+ vermicompost; d. nm+vermicast; e. nm+ inorganic; f. rc+ control; g. rc+vermitea; h. rc+ vermicompost; i. rc+vermicast; j. rc+inorganic; k. pm+control (without fertilizer application); l. pm+ vermitea; m. pm+vermicompost; n. pm+vermicast; o. pm+ inorganic.

Legend: nm (no mulching); pm (plastic mulch); rh (rice hull)

Laboratory experimental set-up

The experiment on postharvest quality evaluation was conducted at the Department of Horticulture, Physiology Laboratory with an average room temperature of 26.2°C. A total of ten sample fruits per treatment, properly tagged and collected to ensure the uniformity of samples at harvest with an average weight ranging from 7-10 g/ fruit.

Postharvest quality evaluation was conducted for 10 days storage duration measuring the parameters with the following rating scale: Visual Quality Rating (VQR)- 9-excellent; field fresh; no defects; 7-good, minor defects (slight surface discoloration); 5- fair; moderate defects (moderate surface discoloration); limit of marketability; 1-poor; serious defects; limit of edibility; 0-non-edible. Firmness- 1-firm; 2- yielding; slightly soft; 3- moderately soft; 4- extremely soft; Shriveling- 0- no shriveling; 1- slight (1-25% surface shriveling); 2-moderate (26-50% surface shriveling); 3- severe (above 50% surface shriveling); A total of 10 sample fruits per treatment were used for the analysis. In terms of general acceptability, fruits were evaluated by 30 panel members consisting of the fruit consumers (15), strawberry enthusiast (10) and trained panel experts (5) using the following rating scale: 5- like extremely, 4- like moderately, 3-like slightly, 2- neither like nor dislike, 1- dislike extremely.

Physicochemical analysis evaluated such as titratable acidity (%) and total soluble solid (°brix), were analyzed in Crop Science Laboratory, University of Southern Mindanao Agricultural Research and Development Center, Philippines. The stepwise procedure in analyzing the Total Soluble Solid includes preparation and extracting the juice of samples fruits using a blender, filtering and measuring the extracts using a refractometer, calibration and reading in °Brix. For titratable acidity (TA), juice of samples was

extracted, diluted in water, pH adjustment using NaOH, titration in a standardized acid, endpoint detection using pH paper and calculation of TA as percentage of citric acid or malic acid equivalent.

Data analysis

The data collected specifically for physicochemical analysis was subjected to appropriate statistical tool analysis. The level of significance was set at 5% and significant differences were analyzed using Friedman Test. Postharvest quality parameters were evaluated using a Likert rating scale with verbal descriptions.

RESULTS AND DISCUSSION

Sensory evaluation: General acceptability parameter

The general acceptability of strawberry in response to application of mulching and organic fertilizers were shown in Table 1a and 1b. Strawberry fruits under plastic mulch condition (Table 1) significantly produced sweeter strawberry fruits with highest average rating scale of 3.85 verbally described as "like very much" with comparable description to strawberry plants planted under the rice hull mulching (3.64). Least acceptability was observed to strawberry plants with no mulching application (3.36) verbally described as "like slightly".

As shown in Table 1b, application of organic fertilizers (vermitea, vermicompost ad vermicast) greatly influenced the general acceptability of harvested strawberry fruits with comparable mean ratings (3.65, 3.71 and 3.63) verbally described as "like very much" with closely related result to strawberry applied with inorganic fertilizer as standard check treatment.

The result implies that the eating quality of harvested strawberry fruits can be influenced by the application of appropriate mulching materials and organic fertilizer application. The findings of the study agreed with the report of Sayği (2021) that organic fertilizers can enhance the quality of the strawberry fruits produced. Reganold *et al.* (2010), also stated that organic strawberry production has great impact on fruit quality rather than the conventional practice of farming that applies synthetic farm inputs. In addition, studies of Cayuela *et al.* (1997); Abu-zahara (2006); Kai and Adhikari (2021); Zhang *et al.* (2020) reported that application of organic fertilizers had a significant positive effect on fruit quality by increasing the starch and soluble solids content of fruit that enhances eating quality and prolong the shelf life reducing perishability. Furthermore, Mohanapriya *et al.* (2024), mentioned that organic fruits and vegetables contain higher amount of vitamins such as ascorbic acid and beta carotene, total polyphenols, dry matter accumulation and fiber content including other mineral nutrients like Ca, Mg, K, Cu, Fe and Zn. In addition, Raihing and Vijayalakhmi (2022), also revealed significant results in terms of the effects of organic fertilizer (vermicompost) in enhancing the yield and quality of black gram.

Moreover, results of Misra and Trirpathi (2011) and Tripathi *et al.* (2015) revealed that the application of various mulching techniques can substantially influenced the ascorbic acid of harvested fruits that causes variability of the eating quality of fresh produced strawberry particularly on the application of plastic mulch.

Physicochemical analysis: Total soluble solids (°Brix) and titratable acidity (%)

In terms of the physicochemical attributes of harvested strawberry fruits. Plants under plastic mulched (8.90 °Brix) significantly influenced the amount of total soluble solids compared to other treatments, the results correlates to the findings of Shukla *et al.* (2021) revealed that maximum soluble solids content was recorded under black mulch whereas the mean minimum soluble solids content was recorded under the control. However, results showed no significant differences in terms of the titratable acidity of strawberry planted to various mulching materials as shown in Table 2a.

Table 1a: General Acceptability of harvested strawberries to application of various mulching materials.

Mulching Description	General acceptability (Rating)*	Verbal application
No mulching	3.36^{b}	Like slightly
Rice hull	3.64^{ab}	Like very much
Plastic mulch	3.85^{a}	Like very much

*- Significant.

Means in a column and row with different letter superscripts are significantly different at 5% level (Friedman test).

Table 1b: General acceptability of harvested strawberry to application of organic fertilizers.

Mulching application	General acceptability (Rating)*	Verbal description
Control (without fertilizer application)	3.35^{b}	Like slightly
Vermitea	3.65^{ab}	Like very much
Vermicompost	3.71^{a}	Like very much
Vermicast	3.63^{a}	Like very much
IF (14-14-14)- standard check	3.55^{ab}	Like very much

*- Significant.

Means in a column and row with different letter superscripts are significantly different at 5% level (Friedman test).

Table 2b revealed significant differences in the total soluble solids of harvested strawberry fruits applied with different organic fertilizers. Vermitea (8.33 °Brix), vermicompost (8.50 °Brix) and vermicast (8.42 °Brix) application significantly enhanced the total soluble solids which were comparable to standard check fertilizer application. The result implies that the application of organic fertilizers not only enhances fruit quality of strawberry but the amount of soluble content as well. Similar findings were observed in the study of Apiryani *et al.* (2021) and Zhang *et al.* (2020) that application of organic fertilizers greatly influenced the amount of organic matter in the soil, improve the soil pH

Table 2a: Total soluble solids (Brix) and titratable acidity (%) of strawberry to application of mulching materials.

Mulching application	Total soluble solids* (°Brix)*	Titratable acidity (%)^{ns}
No mulching	8.30^{b}	1.35
Rice hull	8.35^{b}	1.36
Plastic mulch	8.90^{a}	1.38

ns- Not significant.

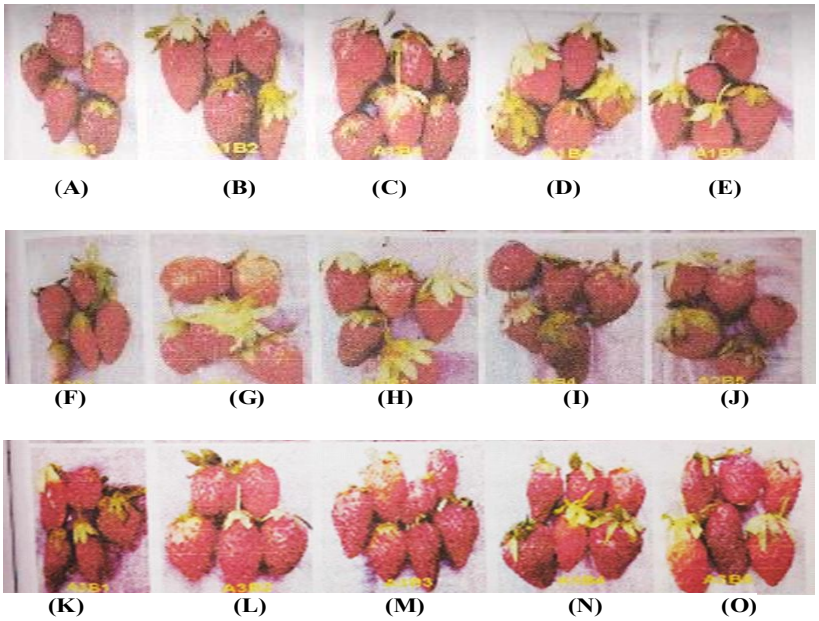
Means in a column and row with different letter superscripts are significantly different at 5% level (Friedman test).

Table 2b: Total soluble solids (°Brix) and titratable acidity (%) of strawberry to application of organic fertilizers.

Mulching application	Total soluble solids* (°Brix)*	Titratable acidity (%)^{ns}
Control	8.17^{b}	1.36
Vermitea	8.33^{a}	1.37
Vermicompost	8.50^{a}	1.36
Vermicast	8.42^{a}	1.34
IF (14-14-14)- standard check	8.33^{a}	1.38

ns- Not significant.

Means in a column and row with different letter superscripts are significantly different at 5% level (Friedman test).



Legend:

A- nm+ control	F- rc+ control	K- pm + control
B- nm + vermitea	G- rc+ vermitea	L- pm + vermitea
C- nm + vermicompost	H- rc+vermicompost	M- pm+ vermicompost
D- nm+ vermicast	I- rc+vermicast	N- pm+ vermicast
E- nm + inorganic (14-14-14)- standard check	J- rc+inorganic (14-14-14) standard check	O- pm+ inorganic (14-14-14) standard check

*nm- no mulching, rc- rice hull, pm- plastic mulch.

Fig 1: Harvested marketable strawberry fruits from plots (treatment combination) applied with various mulching (no mulching, rice hull, plastic mulch) materials and organic fertilizers [control (without application, vermicompost, vermitea and vermicast)].

and enhanced the macro and micronutrients that enhanced quality of fresh produced fruits at harvest.

Postharvest quality assessment

The visual quality rating as shown in Fig 2 was evaluated from the time of harvest until its storability fruit capacity. All fruit samples have VQR 9, described as excellent or without defects and remained in excellent condition for a period of 2 days. However, gradual change and decline in visual quality rating were noted starting on the 3rd day of storage (VQR 7). Fruits harvested in some treatment combinations reached the limit of marketability (VQR 5) at 5 days of storage and some fruits in 4 days. Longer duration of fruits based on the visual quality rating reaching the limit of marketability were among the strawberry fruits harvested from treatment combination under plastic mulch condition applied with vermicast, vermitea, vermicompost and inorganic fertilizers (standard check). Firmness of harvested strawberry fruits shown in Fig 3 remained firm from all the treatment combinations on the first 2 days but started to manifest slight softness at 3rd day of storage. On the other hand, the shriveling index as shown in Fig 4 shows partial shriveling on the 1st day of storage among various treatment combinations and attained moderate shriveling on the 5th day of storage. General observation showed that the application of organic fertilizer and mulching has comparable effects on the firmness of harvested strawberry fruits with the length of storage.

Moreover, longer duration attained the limit of marketability among postharvest quality parameters evaluated were observed from treatment combination applied with plastic mulch and organic fertilizers (vermitea, vermicast and vermicompost). Results of the study correlate to significant findings of Mufty and Taha (2021) that the effect of the application of organic fertilizers increased quality and yield of Albion strawberry variety; same results were also observed to studies of Balci *et al.* (2008) were the effects of organic fertilizers clearly enhanced fruit

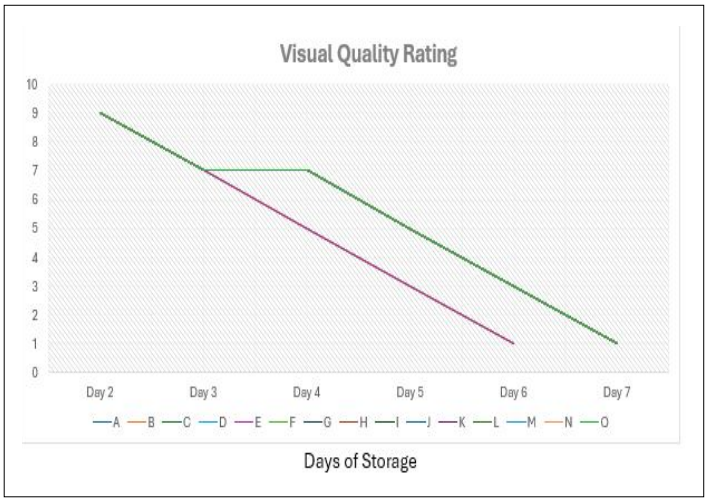


Fig 2: Changes in visual quality of strawberry as affected by mulching and fertilizer applications at 7 days of storage.

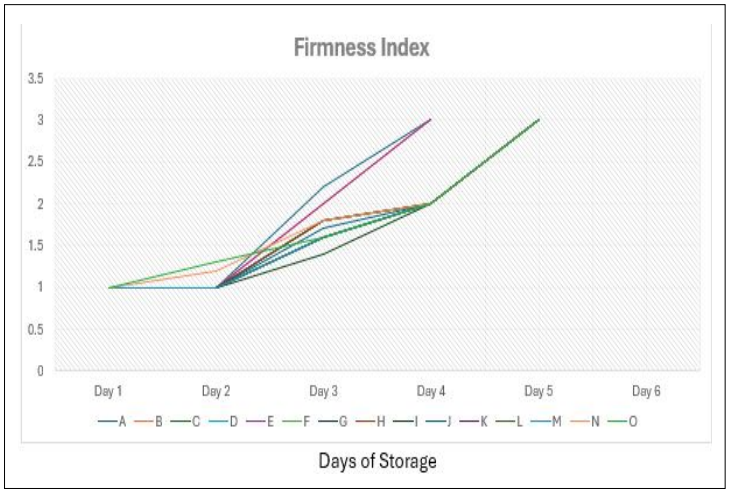


Fig 3: Changes in firmness index of strawberry as affected by mulching and fertilizer applications at 6 days of storage.

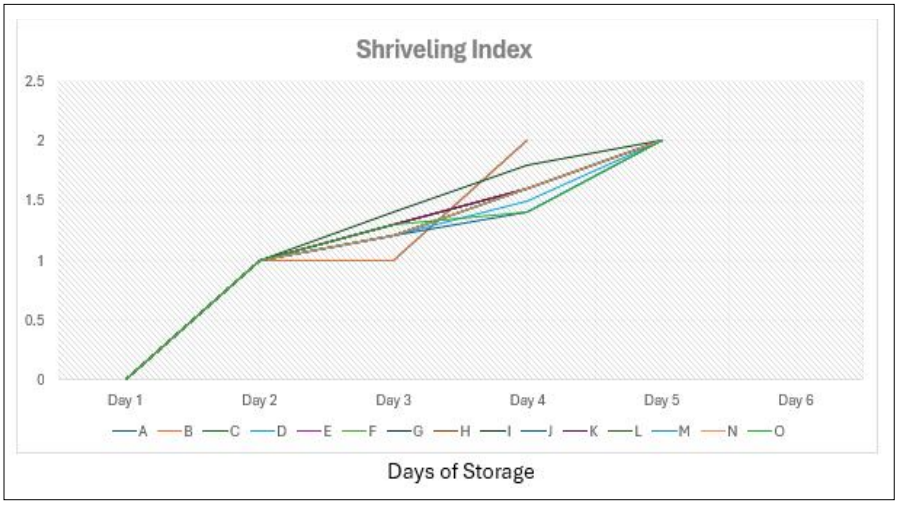


Fig 4: Changes in shriveling of strawberry as affected by mulching and fertilizer applications at 6 days of storage.

quality and yield of Camarose strawberry variety. The results also corroborated with the results of Rahman *et al.* (2015); Singh and Ahmed (2013) and Kher *et al.* (2010) that minimum fruits were obtained to strawberry without mulching while increase and quality of fruits was observed to strawberry under plastic mulch.

CONCLUSION

This study investigated the effects of various types of mulching and organic fertilizers on the postharvest quality and physicochemical analysis of strawberry. Harvested strawberry under plastic mulching applied with the application of different organic fertilizers (vermitea, vermicompost, vermicast) enhanced the postharvest quality of berries particularly on the visual quality appearance and firmness. Moreover, it also enhances the total soluble solids of the berries which significantly contributed to high general acceptability of harvested fruits. Among the various mulching materials application, harvested strawberry fruits under plastic mulch condition produced the most and good quality strawberry fruits. Furthermore, in relation to economic factors, organic fertilizers are locally available with lower production cost that offers long-term benefits in terms of soil health and improvement, increased crop resilience and improved postharvest life of strawberry fruits. Considering the results, it can be concluded and further recommended that the use of plastic mulch applied with organic fertilizers thereby improved quality and enhanced shelf life and contributed to longer perishability of strawberry fruits.

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Author's contribution

The authors carried out experimental design and treatments, developed the conceptual framework, verified the analytical methods and performed the data gathering and monitoring of the study. The author discussed the results and contributed to the final manuscript.

Conflict of interest

No potential conflict of interest was declared by the authors.

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