International Journal of Agricultural Technology 2024 Vol. 20(2):839-856
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Postharvest quality of white-fleshed dragon fruit *(Hylocereus undatus)* var. Vietnam White) as influenced by preharvest fruit bagging

Vallez, J. C.[1*], Gonzaga, A. B. Jr.[1], Magallanes, J. N.[2] and Dollen, A. T.[1]

[1]University of Science and Technology of Southern Philippines−Claveria, Misamis Oriental, Philippines; [2]Biliran Province State University, Biliran, Biliran, Philippines.

Vallez, J. C., Gonzaga, A. B. Jr., Magallanes, J. N. and Dollen, A. T. (2024). Postharvest quality of white-fleshed dragon fruit (*Hylocereus undatus* var. Vietnam White) as influenced by preharvest fruit bagging. International Journal of Agricultural Technology 20(2):839-856.

Abstract Results revealed that black plastic bag exhibited superior performances in most parameters being studied wherein it improved the fresh weight of dragon fruit (662.28g) which was highly comparable to other treatments, fruit length (116.55mm) and equatorial diameter (95.07mm), enhanced the edible rate (73.52%), as well as increasing TSS content with an average of 12.70°Brix, lowered the non-edible weight (143.15g) and peel thickness (2.72mm), as well as the number of fins (18) and maintained the optimum TA content (0.36%). Thus, preharvest colored plastic bagging has influenced the physical and physico-chemical characteristics of *H. undatus* var. Vietnam White at postharvest. The different colors had a distinct effect on the fruit quality. However, the results were inconsistent throughout the sampling period with consideration to the uncontrollable extrinsic factors.

Keywords: Fruit bagging, Fuit quality, *Hylocereus undatus,* Plastic bag

Introduction

The rising awareness of maintaining a healthy diet has led to an increased demand for fruit cultivation. At least 400g of daily consumption of fresh fruits has been advocated by the Food and Agriculture Organization (FAO) of the United Nations and the World Health Organization (WHO). Of all fruits, dragon fruit, also known as 'pitaya' (*Hylocereu*s spp.) from the Cactaceae family has contributed to the rising consumption of exotic fruits. Thus, emerged as the champion in the fruit industry (Le Bellec *et al.,* 2006).

In the Philippines, the dragon fruit cultivation had started on a small scale since 1990s and has expanded to over 400 hectares by 2017, including backyard, small, and medium-scale farm (PSA, 2018). The predominantly cultivated species and marketed in the country are *Hylocereus undatus* (with red peel and

[*] **Corresponding Author**: Vallez, J. C.; **Email:** jhomarievallez0418@gmail.com

white flesh) and *Hylocereus polyrhizus* (featuring red peel and red flesh) (Reynoso, 2012). Apart from Cavite and Ilocos Region, the crop is also gaining its spot in various farms across regions such as Cagayan, Nueva Ecija, Nueva Vizcaya, Bataan, Laguna, Batangas, Rizal, Quezon, and Camarines Norte in Luzon Island; Cebu, Bohol, Iloilo, and Negros in the Visayas; and Davao, Bukidnon and South Cotabato in Mindanao.

In addition to its potential for generating profit, the dragon fruit industry also has drawbacks that affect its production. Throughout the growth and development phases, fruits undergo various physical, physiological, and chemical changes (Sharma *et al.,* 2014). During this period, they become highly vulnerable to issues such as insect pest infestation, bird damage, diseases, and mechanical harm, all of which reduce their commercial value, thereby result in significant economic losses. To address these challenges, various methods have been implemented to enhance fruit quality and appearance, reduce pest and disease impact, with a focus on minimizing chemical applications, particularly through preharvest fruit bagging.

For any fresh market produce, postharvest quality is of utmost consideration. The worldwide introduction of dragon fruit faces challenges due to its lack of knowledge on pre and postharvest management, as emphasized by Centurión-Yah *et al.* (2008). The existing literature on extending the postharvest quality and the impact of preharvest wrapping techniques for dragon fruit is limited in this area.

The colored plastic bags were used, as some other literature revealed that the color influenced the light transmission and acted as filter of Photosynthetically Active Radiation (PAR) (Santosh *et al*., 2017).

Therefore, the study focused on preharvest fruit bagging of white-fleshed dragon fruit (*Hylocereus undatus* var. Vietnam White) using various colors of plastic bags.

Materials and methods

Time and place of the study

The experiment was carried out at the University of Science and Technology of Southern Philippines- Claveria, Research, Development and Extension Unit, 8° 36’ 40.3” N, 124°52’ 51.8” E where it has an elevation of 605 meters above sea level (masl). The soil in the area was generally classified as silty clay, relatively flat and classified under Jasaan Series. The duration of the experimental study was from June to October 2021.

Experimental design and treatments

The study was laid out in a Randomized Complete Block Design (RCBD) with four treatments: T1 – control/ non-bagged, T2 – black plastic bag, T3- red plastic bag and T4 - green plastic bag with three replications. Two sample posts were assigned for each treatment, making a total of 24 posts allocated for the study.

Preparation and application of the treatments

Twenty (20) fruits were wrapped for every treatment. A total of 60 pieces of plastic wrap were used for every batch with 20 pieces of black wrapper and same pieces of red and green. Bags were perforated with 6 holes to allow water and air flow. Fruit wrapping was done at 5-7 Days After Anthesis (DAA). Fruits were wrapped according to treatments while another set of similarly aged fruit were kept unwrapped as control variables.

Cultural management practices

A basal fertilizer consisted of 12 kg of thoroughly decomposed cow manure was applied per post during planting through the ring method application. The posts were positioned at 3m x 3m. To prevent the planted cuttings from toppling, each cutting was tied with a plastic straw. Support posts were set up with two horizontal metal pieces, and a used motorcycle tire was mounted on each post, respectively.

Fertilization

A recommended rate of 60-120-60 kg/ha of NPK was applied every 30th day of the month, a month thereafter from the date of planting (MAP). Regular pruning of emerging water sprout was done to eliminate nutrient competition. Similarly, pests and disease monitoring were done regularly.

Harvesting

Harvesting was done at 35 DAA, it was harvested in the morning, marked according to treatment and placed in crates for hauling.

Postharvest quality analysis

Postharvest quality was assessed through its physical and physicochemical characteristics. Ten fruits were selected from each treatment for the postharvest evaluation. Data gathering on physical characteristics were done immediately after harvest. Fruits were then placed in a room with ambient temperature for about 24 hours for resting and in preparation for the physicochemical evaluation through destructive method.

Physical characteristics quality analysis

The peel and fruit weight were obtained using a digital weighing scale, expressed in grams. Polar and equatorial diameter as well as peel thickness were measured using a digital Vernier caliper and expressed in millimeter. Pulp yield was calculated through the formula: fresh weight – peel weight x 100, expressed as percentage.

Physicochemical characteristics quality analysis

Fruit firmness was determined using a semi-manual penetrometer, with results expressed in Newton (N). Thereafter, the fruit pulp was mashed and the juice was analyzed for the TSS reading using a refractometer. Pulp pH was measured using a digital pH meter. Titratable acidity was measured through the titration of mixture (1 gram of macerated sample with 50ml of water and with 3 drops of 1% phenolphthalein indicator) with 1 Normal Sodium Hydroxide (NaOH). This was then calculated through the formula:

$$\%\ \text{TA(predominant acid)} = \frac{\text{V x N NaOH x mEq}}{\frac{\text{fresh wt of sample}}{\text{vol.of water added+fresh wt of sample}} \text{ x vol.of aliquot}} \text{ x } 100$$

Results

Agrometeorological data of Claveria Misamis Oriental

Result showed the precipitation and temperature of Claveria Misamis Oriental from June to October 2021 (Figure 1). In June, mean daily maximum temperature hovers around 25°C and recorded the highest amount of precipitation throughout the four collection seasons which is 273mm. July had 248mm of rain with mean daily maximum temperature of 25°C. Meanwhile, August and September had 243mm and 216mm of rain, respectively with mean daily maximum temperature of 26°C.

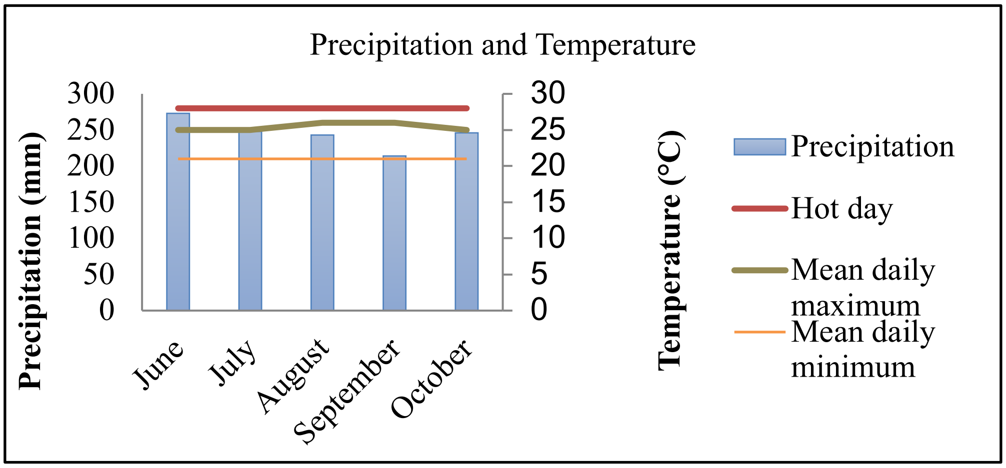

Figure 1. Precipitation and Temperature of Claveria Misamis Oriental from June to October 2021. Source: Meteoblue, 2022

Physical characcteristics

Fresh weight

It showed that fresh weight of *H. undatus* var. Vietnam White was significantly influenced by preharvest bagging using different colors of plastic (Table 1). On July 2021, T4 obtained the highest fruit weight of 586.70g which was relatively similar to T3 (583.44g) and was slightly comparable to T2 (551.61g) while the lowest was recorded in T1 (477.36g). Meanwhile, fruit weights in October were relatively similar but higher than in previous months, with the exception of T4 (562.77g), which decreased 4.08%. T2 (662.28g) had the highest weight, followed by T1 (629.46g) and T3 (627.74g).

Fruit size

Bagged fruits influenced the longitudinal length and equatorial diameter of *H. undatus* more than non-bagged fruits, regardless of the plastic bag color (Table 2).

Fruit morphology

Peel weight and thickness showed significant difference as influenced by preharvest fruit bagging (Table 3). Throughout the sampling period, T4 obtained heavier and thicker peel than the other treatments, with the highest peel weight of 183.3g and the thickest peel of 3.86mm.

Contrastingly, the lightest peel was obtained from T3 (135.8g) which was relatively similar to T2 (143.15g). Meanwhile, the thinnest peel was noted at T2 (2.72mm).

Table 1. Fresh weight of white-fleshed dragon fruit as influenced by preharvest fruit bagging during the four sampling periods

Treatment	Month	Fresh Weight (g)
T1- Control	July	477.36d
	August	531.78bcd
	September	593.78abc
	October	629.46ab
T2- Black plastic bag	July	551.61bcd
	August	565.99bc
	September	592.90abc
	October	662.28a
T3- Red plastic bag	July	583.44abc
	August	465.42d
	September	535.69bcd
	October	627.74ab
T4- Green plastic bag	July	586.70abc
	August	508.43cd
	September	532.29bcd
	October	562.77bc
F-value		0.00
Std. Error		5.77
Coef. Var.		22.47

Values with different letters are significant with each other, $p<0.05$=significant and $p<0.01$= highly significant

Table 2. Fruit size of *H. undatus* as influenced by preharvest fruit bagging during the four sampling periods

Treatment	Month	Longitudinal Length (mm)	Equatorial Diameter (mm)
T1- Control	July	103.75d	87.62de
	August	114.69bc	94.59b
	September	112.38bc	93.60bc
	October	112.31bc	92.10c
T2- Black plastic bag	July	116.55ab	95.07ab
	August	113.97bc	91.15c
	September	113.88bc	92.61c
	October	112.48bc	92.65bc
T3- Red plastic bag	July	113.27bc	94.25b
	August	114.05bc	91.16c
	September	108.57cd	89.90c
	October	114.59bc	91.99c
T4- Green plastic bag	July	122.92a	98.89a
	August	115.05bc	86.86e
	September	109.79bcd	88.97c
	October	114.73bc	88.35cde
p-value		0	0
Std. Error		0.41	0.35
Coef. Var.		7.90	8.28

Values with different letters are significant with each other, $p<0.05$=significant and $p<0.01$= highly significant

Table 3. Pericarp characteristics of *H. undatus var. Vietnam White* as influenced by preharvest fruit bagging during the four sampling periods

Treatment	Month	Peel Weight (g)	Peel Thickness (mm)
T1- Control	July	152.69d	3.87a
	August	153.30d	2.97bc
	September	180.51ab	2.99bc
	October	193.26a	3.50ab
T2- Black plastic bag	July	143.15de	3.33abc
	August	171.11bc	3.25abc
	September	160.23cd	2.72c
	October	187.39a	3.81a
T3- Red plastic bag	July	171.12bc	3.91a
	August	146.84de	3.36abc
	September	135.88e	3.04bc
	October	187.26a	3.65ab
T4- Green plastic bag	July	178.03abc	3.83a
	August	178.60abc	3.86a
	September	167.56cd	3.26abc
	October	183.13ab	3.54ab
p-value		0.00	0.00
Std. Error		1.85	0.04
Coef. Var.		24.11	25.78

Values with different letters are significant with each other, $p<0.05$=significant and $p<0.01$= highly significant

Number of fins, fin length and fin base width

The number of fins on *H. undatus* showed significant variances (Table 4). It was found out that T3 has the highest number of fins (23), also had the longest fin length of 54.15mm and widest fin base (41.79mm). Whereas, T2 has the lowest number of fins (18), T4 had the shortest fin length of 36.77mm and the least fin width of 34.33mm.

Table 4. Number and size of fins of *H. undatus* as influenced by preharvest fruit bagging during the four sampling periods

Treatment	Month	No. of Fins	Fin Length (mm)	Fin Base Width (mm)
T1- Control	July	19def	40.97bc	35.88ab
	August	20de	38.86bc	36.50ab
	September	22abc	41.77bc	34.49b
	October	21abc	44.36abc	38.82ab
T2- Black plastic bag	July	18g	37.36c	36.22ab
	August	21bc	37.51bc	36.85ab
	September	20bcd	37.64bc	36.80ab
	October	22abc	42.23bc	35.88ab
T3- Red plastic bag	July	18fg	38.36bc	41.79a
	August	23a	45.73abc	36.19ab
	September	21abc	40.81bc	37.12ab
	October	22ab	54.15a	38.66ab
T4- Green plastic bag	July	18efg	36.77c	34.95ab
	August	22abc	48.69ab	34.33b
	September	22ab	43.41abc	35.53ab
	October	20cde	43.45abc	38.57ab
p-value		0.00	0.00	0.21
Std. Error		0.14	0.61	0.38
Coef. Var.		14.61	31.60	22.61

Values with different letters are significant with each other, $p<0.05$=significant and $p<0.01$= highly significant

Partition of endocarp and exocarp

Positive influence of bagging was significantly observed in T2 with the highest pulp percentage of 73.52% and gained the lowest peel of 26.48% in the postharvest month of July (Table 5). On contrary, T4 gained the least pulp (64.37%) and the highest partition of exocarp (35.63%), regardless of the sampling period.

Table 5. Partition of endocarp and exocarp of white-fleshed dragon fruit as influenced by preharvest fruit bagging during the four sampling periods

Treatment	Month	%Endocarp	%Exocarp
T1- Control	July	66.67de	33.33ab
	August	71.21bc	28.79cd
	September	69.50c	30.50bcd
	October	68.50c	31.50bcd
T2- Black plastic bag	July	73.52a	26.48e
	August	69.65bc	30.35cd
	September	71.86abc	28.14cde
	October	71.23bc	28.77cd
T3- Red plastic bag	July	70.34bc	29.66cd
	August	68.12cd	31.88bc
	September	72.88ab	27.12de
	October	69.93bc	30.07cd
T4- Green plastic bag	July	69.88bc	30.12cd
	August	64.37e	35.63a
	September	68.18cd	31.82bc
	October	67.23cde	32.77abc
p-value		0.00	0.00
Std. Error		0.38	0.28
Coef. Var.		8.94	20.44

Values with different letters are significant with each other, $p<0.05$=significant and $p<0.01$= highly significant

Physicochemical characteristics

Firmness showed an inconsistent response to preharvest colored bagging (Figure 2). Irrespective of the treatments, fruits exhibited relatively higher firmness values at postharvest in July than the rest of the months, wherein T3 measured the highest (89.47N) while the lowest value was noted in T4 (86.89N). However, an abrupt decline was observed in red bagged fruits (T3) during August, September and October (16.47% decreased from July). Other bagged fruits (T2 and T4) also exhibited lower firmness values during the said months.

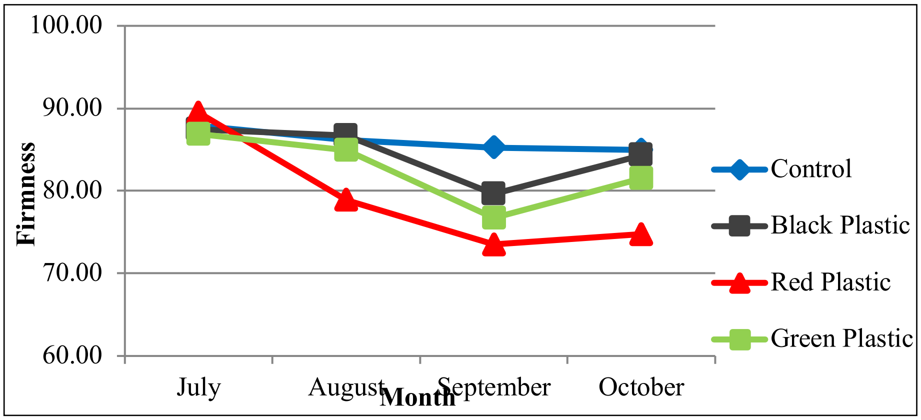

Figure 2. Fruit firmness of white-fleshed dragon fruit as influenced by preharvest fruit bagging during the four sampling periods

Total Soluble Solids (TSS):TSS content varied throughout the four collection seasons (Figure 3). In July and September, there was no significant difference in the postharvest quality of bagged fruits. Meanwhile, during postharvest in August and October, T2 had a higher TSS than the other treatments, measuring 11.84 °Brix and 12.70 °Brix, respectively, while T1 had the lowest (10.41°Brix and 11.74°Brix, respectively).

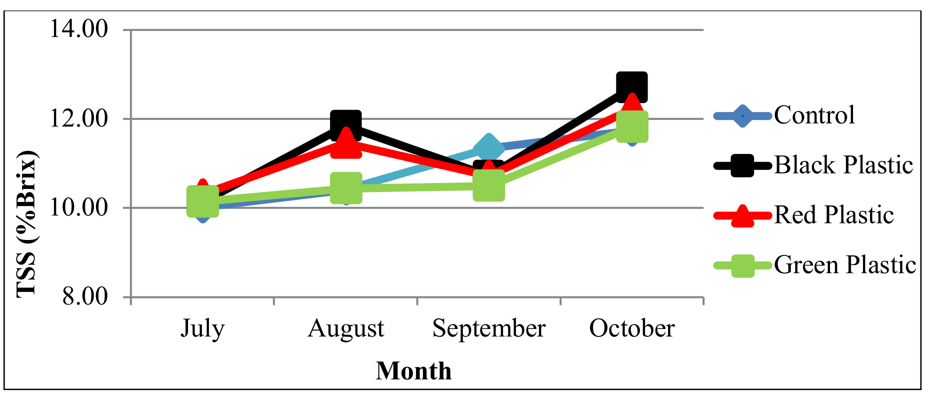

Figure 3. Total Soluble Solid (TSS) of *H. undatus* var. Vietnam White as influenced by preharvest fruit bagging during the four sampling periods

Fruit pH statistically revealed significant differences throughout the four collection seasons (Figure 4). Irrespective of the treatments imposed, fruits harvested during August and October had significantly higher pH compared to those harvested in July and September.

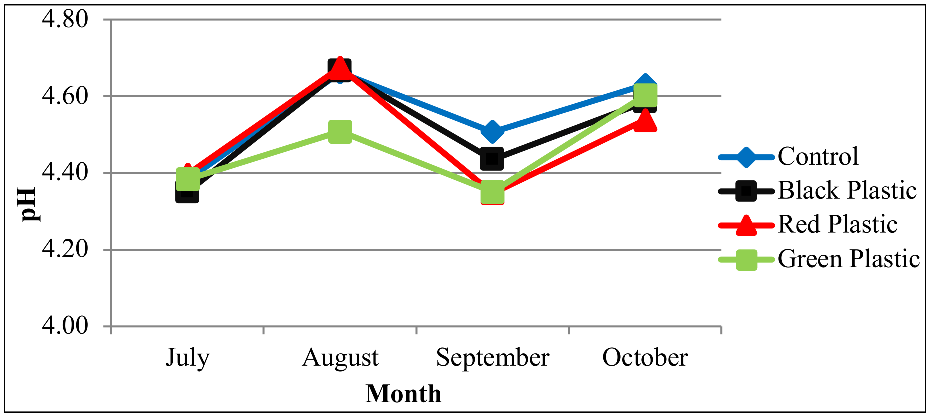

Figure 4. *H. undatus* var. Vietnam White pH as influenced by preharvest fruit bagging during the four sampling periods

Titratable acidity (%TA): Regardless of the sampling period and plastic bag color, the fruits had higher %TA in comparison with the non-bagged fruits. The graph gives off an accelerating trend for *H. undatus* pre-bagged with green plastic garnering the highest 0.4% TA (Figure 5).

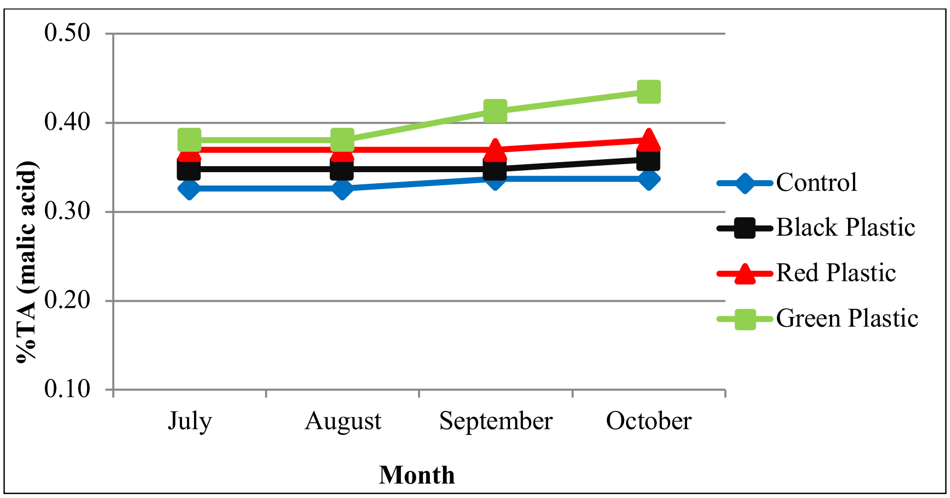

Figure 5. Titratable Acidity (TA) of *H. undatus* as influenced by preharvest fruit bagging in the four sampling periods

Discussion

According to Bindi *et al.* (2001), different environmental elements affect the growth and development of fruits and vegetables, with temperature as the primary factor affecting fruit development and ripening (Chonhenchob *et al*., 2011). In this study, it was found out that fresh weight of black plastic bagged fruits was significantly higher than those of all other treatments during the four sampling periods. The *H. undatus* var. Vietnam White pre-wrapped with black plastic bag have a very comparative fruit weight (662.28g) compared to the findings of Chowdhury *et al*. (2020) with white-fleshed dragon fruit wrapped in a black polythene bag which only had 368.40g highest fresh weight. This is also in agreement to the findings of Yang *et al*. (2009) wherein there was a significant difference in fruit weight with respect to bagging treatments and control during cross-winter off season.

The bag type and bagging date had a significant impact on fruit size; however, an improvement may be caused by changes in the microclimate inside the bag (Sharma *et al*., 2014). The increase in fruit diameter was in agreement to the findings of Hossain *et al*. (2020) that bagged mango fruits have wider diameter than non-bagged fruits. Moreover, Zhi *et al*. (2021) observed that bagging fruits with aluminum polyethylene bags increased their length and width by 12.54% compared to unbagged fruits. Furthermore, a round or oblong fruit form was attributed to the fact that the fruit length consistently increased more rapidly than the its diameter (Meten, 2003).

In terms of of fruit morphology, thicker peeled fruits are less likely to be damaged during transport and handling and have a lower risk of disease ingress (Petracek, 1996). Somehow, the result positively differed from the previous findings of Hossain *et al.* (2021) wherein *H. undatus* bagged at 12 DAA using black polythene bag had obtained the maximum peel weight of 88.53g which was significantly lower than T2 in this study (143g). In terms of peel thickness, Hossain *et al*. (2021) reported 3.9mm thickness which was significantly thicker than the findings in September on bagged *H. undatus* with only 2.72mm. Further, the decrease in peel thickness in black plastic bagged fruits may have resulted from the low light intensity and high humidity inside the bag which influenced the cell structure and peel thickness of the fruit (Singh *et al*., 2021). The thinning of the fruit's skin increases its susceptibility to mechanical harm and phytopathogenic agent attack (Magalhaes *et al*., 2019). There were no published studies on the influence of green and red plastic bags on the weight and thickness of fruit peels. However, preharvest bagging on *H. undatus* was not recommended since it reduced the weight and thickness of the peel, especially in the post-harvest month of September; whereas green bags significantly contributed to the increase in the peel thickness (3.86mm) and weight (183g), making the fruit less prone to injury.

As reported by Mizrahi (2015), throughout all stages of fruit development, the fin exhibited greater density of active stomata than the other portions of the fruit peel, approximately 3-4 times higher resulting on a faster water transpiration (Kammapana *et al*., 2013). It revealed that the greater and wider the dragon fruit fins, the faster was the fruit degradation which was collectively observed during August and October sampling periods regardless of the treatments applied. Furthermore, according to Rodeo *et al*. (2018), *H. undatus* has the highest number of stomata in its scales, making it more vulnerable to shriveling. It suggested that fruits in red plastic bags would experience rapid transpiration, which ultimately lower their marketability, visual appeal, storage and life span. Positive influence of bagging was observed on % edible rate of white-fleshed dragon fruits. The study of Ortiz and Takahashi (2015) confirmed that the edible portion of the fruit (pulp) increases while the pericarp decreases, indicating this as a characteristic of the species. The current result was in agreement to the findings of Tran *et al*. (2015) wherein white-fleshed dragon fruit cv. Chuchi Liu wrapped with polyethylene plastic black bag had a higher edible rate (68.5%) than those unbagged (61.1%). The data further implied that *H. undatus* bagged with black plastic during fruit development produces the least exocarp and thus, less food waste.

Firmness is one of the several determining factors of fruit quality (Harker *et al*. 1997). The results could be due to the agro-climatic conditions of Claveria Misamis Oriental during the developmental period (June), which had 273mm of rain and approximately 29 rainy days which could have delayed the softening of the fruit as excessive rainfall enhanced the fruit's turgor pressure during the growing period (Farcuh and McPherson, 2021). Other bagged fruits (T2 and T4) also exhibited lower firmness values during the said months. This could be associated to the artificially elevated humid environment of fruit bagged with plastic which could influenced the structure and/or composition of the cuticle and/or lenticels (Mathieu and Jacques, 2007). High humidity surrounding fruit within plastic bags may have slowed the production of their cuticle, rendering them more prone to physical damage (Joyce *et al*., 1997). Thus, to attain firmer fruits, it is recommended to bag fruits with red plastic during June (developmental period).

The current findings on total soluble solids have arisen due to the rising temperature and relative humidity inside the bag, combined with the maximum temperature and humidity recorded in Claveria Misamis Oriental during the developmental period (July and September) which was 25°C and 26°C; respectively, which might have accelerated the maturation and ripening of the fruit at 35 DAA, thereby increased the TSS content. This interpretation was attributed to the similarity between the black plastic mulch and the black plastic bag, which both effectively absorbed the majority of UV, visible, and infrared wavelengths of incoming solar radiation (Lamont, 1999) resulting in less light hitting the fruit's surface while raising the temperature and relative humidity in its surroundings (Ali *et al*., 2021). Hence, the use of black plastic bags during July and September (developmental period) was recommended to obtain sweeter fruits at postharvest. One of the most significant environmental factors influencing fruit growth and ripening is temperature (Chonhenchob *et al.,* 2011), and the shortest fruit maturity duration was observed under black polythene bagged fruits (Chowdhury *et al*., 2020). Furthermore, Silva *et al*. (2015) discovered that TSS content increased with maturation and Junior *et al*., (2021) also found out that white-fleshed dragon fruit harvested at > 75% peel redness stage (more advanced ripeness) had higher soluble solids (15.67°Brix) than those harvested at 25% peel redness stage (12.17°Brix), which was higher than in the current study.

Higher pH values might have resulted from the agrometeorological condition of Claveria, Misamis Oriental during the developmental period (July and September, respectively) wherein the average precipitation was 248mm and 214mm and maximum temperature of 25°C and 26°C, which possibly accelerated the maturation and ripening of dragon fruit thereby increased the pH, as TSS had also increased. The results revealed that fruits with higher pH values, harvested in August and September, were already mature and ripe at 35 DAA, which corresponded to a lower acidity. This happens when the organic acids present in the fruit gradually declined as ripening progresses while the concentration of soluble solid increases (Junior *et al*., 2021).

There was a significant difference on titratable acidity content in reference to malic acid as the pre-dominant organic acid of *H. undatus* bagged using different colors of plastic. Dragon fruit contains several organic acids, which significantly influenced its acidity as well as its flavor, aroma, color, and other organoleptic characteristics (Karunakaran *et al*., 2019). In an experiment done by Nerd and Mizrahi (1999), it was observed that TA values lower than 1% resulted in a satisfactory taste and sweetness in dragon fruit. The findings in this study were in consonance to the findings of Abbasi *et al*. (2014) wherein newspaper- wrapped fruits harvested during mature green and yellow stage had significantly higher values of acidity (0.66% and 0.68%, respectively) in comparison to non-bagged fruits (0.54% and 0.55%, respectively). The dragon fruit pulp composed of about 90% of malic acid, while the remaining portion comprises of citric acid and ascorbic acid (Inoue *et al*., 2001; Nomura *et al*., 2005). When the fruit is exposed to excessive sunlight, the organic acids particularly the malic acid degrades followed by citric acid, thereby reducing the amount of titratable acidity (Scafidi, 2013; Matto *et al*., 1975; Salunkhe and Desai, 1984). Results further revealed that fruit bagging had maintained higher levels of titratable acids (malic acid) as plastic bags provide protection to the fruit from an increase exposure to sunlight.

Thus, preharvest colored plastic bagging has influenced the physical and physico-chemical characteristics of *H. undatus* var. Vietnam White at postharvest. The different colors had a distinct effect on the fruit quality. However, the results were inconsistent throughout the sampling period with consideration to the uncontrollable extrinsic factors.

Acknowledgments

The authors are grateful to the University of Science and Technology of Southern Philippines-Claveria for their invaluable support during the conduct of this study.

References

Abbasi, N. A., Amjad, M., Chaudhary, M., Ikram, A., Hussain, A. and Ali, I. (2014). On tree fruit bagging influences quality of guava harvested at different maturity stages during summer. International Journal of Agriculture and Biology, 16.

Ali, M. M., Anwar, R., Yousef, A. F., Li, B., Luvisi, A., Bellis, L. D. and Chen, F. (2021). Influence of Bagging on the Development and Quality of Fruits. Plants, 10:358.

Bindi, M., Fibbi, L. and Miglietta, F. (2001). Free Air CO2 Enrichment (FACE) of grapevine (*Vitis vinifera* L.): II. Growth and quality of grape and wine in response to elevated CO2 concentrations. European Journal of Agronomy, 14:145-155.

Chonhenchob, V., Kamhangwong, D., Kruenate, J., Khongrat, K., Tangchantra, N., Wichai, U. and Singh, S. P. (2011). Preharvest bagging with wavelength-selective materials enhances development and quality of mango (*Mangifera indica* L.) cv. Nam Dok Mai #4. Journal of the Science of Food and Agriculture, 91:664-671.

Centurion-Yah A. R., Solís Pereira S., Saucedo Veloz C., Baéz Sañudo R. and Sauri Duch E. (2008). Physical, chemical and sensory changes in pitahaya fruits (*Hylocereus undatus*) during their development. Rev Fitotec Mex, 31:1-5.

Chowdhury, S., Hossain, M. M., Rahim, M. A. and Ferdous, T. (2020). Postharvest quality and shelf life of dragon fruit *(Hylocereus* spp.*)* as influenced by preharvest fruit bagging materials. Journal of Agriculture, Food and Environment, 6:37-45.

Farcuh, M. and McPherson, C. (2021) Fruit Texture and the Science Behind It (FS-1189). University of Maryland Extension. Retrieved from https://extension.umd.edu/resource/fruit-texture-and-science-behind-it-fs-1189/

Harker, F. R., Redgwell, R. J., Hallett, I. C., Murray, S. H. and Carter, G. (1997). Texture of fresh fruit. Horticultural reviews, 20:121-224.

Hossain, M. J., Hossain, M. M., Rabbani, M. G., Hafiz, MMH and Islam, MZ. (2020). Effects of preharvest fruit bagging on postharvest quality and shelf life of mango cv. Amrapali. Journal of Bangladesh Agricultural University, 18:61- 67.

Hossain, M. M., Chowdhury, S. and Rahim, M. A. (2021). Postharvest quality and shelf life of dragon fruit (*Hylocereus* spp.) as influenced by preharvest fruit bagging materials. Journal

of Agriculture, Food and Environment (JAFE)| ISSN (Online Version): 2708-5694, 1:33-40.
Inoue, H., Awaguni, Y. and Ikemiya, H. (2001). Characteristics in pitaya fruit. Japanese Journal of Tropical Agriculture, 45:7-8.
Joyce, D. C., Beasley, D. R. and Shorter, A. J. (1997). Effect of preharvest bagging on fruit calcium levels and storage and ripening characteristics of 'Sensation' mangoes. Australian Journal of Experimental Agriculture, 37:383-389.
Junior, I. M. R., Magalhães, D. S., Rodrigues, F. A., Pasqual, M. and Pio, L. A. S. (2021). Fruit quality and harvest point determination in white-fleshed dragon fruit. Research, Society and Development, 10:e11810716287-e11810716287.
Kammapana, L., Buanong, M., Techavuthiporn, C., Jitareerat, P., Wongs-Aree, C., Yamauchi, N. and Srilaong, V. (2013). SEM Studies on the Morphology of 'White Pulp' Dragon Fruit. Acta Hortic, 989:85-90. DOI: 10.17660/ActaHortic.2013.989.8
Karunakaran, G., Arivalagan, G. K. M. and Sriram, S. (2019). Dragon fruit country report from India. FFTC Agricultural Policy Platform, FFTC-AP, Food and Fertilizer Technology for the Asian and Pacific Region.
Lamont, W. J. (1999). Vegetable production using plasticulture. Food and Fertilizer Technology Center.
Le Bellec, F., Vaillant, F. and Imbert, E. (2006). Pitahaya (*Hylocereus* spp.): A new fruit crop, a market with a future. Fruits, 61:237-250.
Magalhaes, D. S., Ramos, J. D., Pio, L. A. S., Boas, E. V. D. B. V., Pasqual, M., Rodrigues, F. A. and dos Santos, V. A. (2019). Physical and physicochemical modifications of white-fleshed pitaya throughout its development. Scientia horticulturae, 243:537-543.
Mathieu L. and Jacques J. (2007). An overview of preharvest factors influencing mango fruit growth, quality and postharvest behaviour. Brazilian Journal of Plant Physiology, 19:287-298.
Mattoo, A. K., Murata, T., Pantastico, E. B., Chachin, K., Ogata, K. and Phan, C. T. (1975). Chemical changes during ripening and senescence. In: Post Harvest Physiology, pp.13-15.
Meten, S. (2003). A review of Hylocereus production in the United States. Journal of the Professional Association for Cactus Development, 5:98-105.
Meteoblue. (2022). Claveria Philippines. Retrieved from: https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/claveria_philippines_1717351
Mizrahi, Y. (2015). Thirty-One Years of Research and Development in the Vine Cacti Pitaya Cultivation in Israel. Improving Pitaya Production and Marketing, 1-18.
Nerd, A. and Mizrahi, Y. (1999). The effect of ripening stage on fruit quality after storage of yellow pitaya. Postharvest Biology and Technology, 15:99-105.
Nomura, K., Ide, M. and Yonemoto, Y. (2005). Changes in sugars and acids in pitaya (*Hylocereus undatus)* fruit during development. The Journal of Horticultural Science and Biotechnology, 80:711-715.
Ortiz, T. A. and Takahashi, L. S. A. (2015). Physical and chemical characteristics of pitaya fruits at physiological maturity. Genetics and Molecular Research, 14:14422-14439.
Petracek, P. D. (1996). Peel Morphology and Blemishes. Citrus Research and Education Center, Florida Department of Citrus, Lake Alfred. Florida, p 108-118.
PSA (Philippine Statistics Authority) (2018). Volume of Production and Area Planted for Dragon Fruit in the Philippines (2012-2017).
Reynoso, Z. B. (2012). Enter the dragon fruit. BAR Research and Development Digest Vol.14 No.4.

Rodeo, A. J., Castro, A. C. and Esguerra, E. B. (2018). Postharvest handling of dragon fruit (*Hylocereus* spp.) in the Philippines, pp.125-131.

Salunkhe, D. K. and Desai, B. B. (1984). Postharvest Biotechnology of Vegetables, Vol. 1, pp. 55-82.

Santosh, D. T., Tiwari, K. N. and Reddy, R. G. (2017). Banana Bunch Covers for Quality Banana Production – A Review. International Journal of Current Microbiology and Applied Sciences, 6:1275-1291.

Scafidi, P., Pisciotta, A., Patti, D., Tamborra, P., Di Lorenzo, R. and Barbagallo, M. G. (2013). Effect of artificial shading on the tannin accumulation and aromatic composition of the Grillo cultivar (*Vitis vinifera* L.). BMC plant biology, 13:1-11.

Sharma, R. R., Reddy Sanikommu, V. R. and Jhalegar, M. J. (2014). Preharvest fruit bagging: a useful approach for plant protection and improved post-harvest fruit quality—a review. Journal of Horticultural Science and Biotechnology. 89:101-113.

Silva, M. A. P. D., Plácido, G. R., Caliari, M., Carvalho, B. D. S., Silva, R. M. D., Cagnin, C. and Silva, R. C. F. D. (2015). Physical and chemical characteristics and instrumental color parameters of passion fruit (*Passiflora edulis* Sims). African Journal of Agricultural Research, 10:1119-1126.

Singh, A., Meena, H. M., Santra, P., Meghwal, P. R. and Kumar, P. (2021). Influence of preharvest fruit bagging and plant cover on peel colour, physical appearance and quality traits of pomegranate fruits in arid conditions. Journal of Environmental Biology, 42:1560-1566.

Tran, D. H., Yen, C. R. and Chen, Y. H. (2015). Effect of bagging on fruit characteristics and physical fruit protection in red pitaya (*Hylocerus* spp.). Biological Agriculture and Horticulture, 31:158-166.

Yang, W, H., Zhu, X. C., Bu, J. H., Hu, G. B., Wang, H. C. and Huang, X. M. (2009). Effects of bagging on fruit development and quality in cross-winter off-season longan. Scientia Horticulturae, 120:194-200.

Zhi, C., Ali, M. M., Zhang, J., Shi, M., Ma, S. and Chen, F. (2021). Effect of Paper and Aluminum Bagging on Fruit Quality of Loquat (*Eriobotrya japonica* Lindl.). Plants, 10:2704.

(Received: 27 February 2023, Revised: 5 March 2024, Accepted: 9 March 2024)