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Effect of Fruit Bagging Colors on the Post-Harvest Quality of Dragon Fruit (*Hylocereus polyrhizus*)

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***Abstract* – Low quality associated with "improper cultural management is paramount in the dragon fruit industry in the Philippines. Enhancing postharvest quality by fruit bagging could somehow minimize yield losses for farmers. This study was conducted to assess the effects of the different bagging colors on the duration of fruit maturity and the postharvest quality of fruits with the following bagging color treatments: T1 (white); T2 (red); T3 (blue); T4 (green) and T5 (control-unbagged). The Red-colored cellophane significantly affected the skin color specifically on a* coordinates; T1 (white) has the highest electrical conductivity (EC) and vitamin C content with 2.66 mS/cm (which could amplify fruit deterioration) and 10mg/kg. T3 (blue) had the least EC (2.23 mS/cm) that could extend postharvest life, and white cellophane had the most vitamin C content with 10mg/100g of dragon fruit. None of the fruit bagging colors gave significant results on sensory evaluation and proximate analysis of dragon fruit.**

***Keywords* – Electrical Conductivity, a* Coordinates, Bagging Colors, Cellophane, Vitamin C.**

I. INTRODUCTION

The dragon fruit is a long-day plant with a beautiful large creamy white colored and aromatic flower that typically blooms at night and was given a tag line as "Noble Woman" or "Queen of the Night". Apart from its delicious taste, dragon fruit is low-calorie, high in fiber, and provides a good amount of several vitamins and minerals. According to Mercola (2017), red pigments in dragon fruit also contain the highest amount of lycopene, antioxidants like vitamin C (said to be nearly 10 percent of the daily recommended value), flavonoid, and phytoalbumins which can help prevent cancer cells formation. Its edible seeds are rich in polyunsaturated fats, like omega-3 and omega-6 fatty acids, which have been proven to lower the risk of cardiovascular disorders (Mordor Intelligence 2021).

The export potential and high demand from the local market for dragon fruit have marked its economic importance. In the Philippines, the low-quality dragon fruits in the local markets are reported to be associated with "improper cultural management of the crop" and may be the reason why locally produced dragon fruits do not pass standards for export. Enhancing postharvest quality through fruit bagging could be an option to meet market standards. Hossain et al (2021) reported that fruit bagging has become a fundamental component of fruit cultivation because of the wide benefits it provides. It does not only protect from biotic but abiotic stresses as well which enhances the overall fruit quality and therefore the basis for the conduct of this study.

II. MATERIALS AND METHODS

Experimental Design, Treatments, and Identification of Samples

A total of fifteen (15), three-year-old non-bearing dragon fruit plants at a 3x3 m planting distance between poles containing 4 plants pole^{-1}, of almost the same crop stand was used in the study. The experiment was laid out in a Randomized Complete Block Design with five treatments and three replications. Upon fruit set, ten fruit

samples per treatment were tagged, labeled, and bagged with cellophane with the following colors as treatments: T_1 white; T_2 red; T_3 blue; T_4 green and T_5 unbagged/control.

Fruit Sample Preparation

Immediately after harvest, newly harvested fruits were weighed/measured to obtain the fruit weight and size by measuring the length and width of the fruit. Fruit samples were then sent to the postharvest laboratory of the Horticulture Department, Visayas State University for postharvest laboratory analyses and evaluation.

III. Results and Discussion

Physical Characteristics of Dragon Fruit

Shown in Table 1 are the physical characteristics of dragon fruit consisting of the average fruit weight, average fruit length, average fruit diameter, and skin color of dragon fruit wrapped with different colors of bagging material. Results revealed that T_2 (red-colored cellophane) significantly affected the coordinates a* 40.24 (representing the red/green color). T_4 green-colored cellophane (35.14) is slightly higher than T_1 white (33.46), T_3 blue (30.94), and T_5 control (30.93) but were found to be statistically comparable. This result suggests the dominance of red over green color implying the presence of more anthocyanin pigments in dragon fruits.

According to Khoo et al (2017) red, purple, and blue colors in fruits and vegetables are due to the presence of anthocyanin pigments. Hence, the findings of this study are in coherence with that of Asrey et al (2020) who discovered that the highest anthocyanin content was found in fruits wrapped in red-colored bags. These further suggest that there is a positive effect of red bags on pigment synthesis and reduction of anthocyanin breakdown from sunlight (Kim et al. 2010) as exhibited by the dragon fruits wrapped with red-colored cellophane. The L* (lightness or luminosity) and b* for yellow/green coordinates, on the other hand, were not affected by the red-color bagging material. The diverse effect of bagging color according to Chonhenchob et al (2011) could be due to differences in the light reflectance, absorbance, or transmission patterns of each bag in the visible, far-red, and/or infra-red regions of the spectrum.

Meanwhile, other parameters like average fruit weight, fruit length, and fruit diameter, were not affected by either white, blue, or green colors of bagging materials. This is consistent with the findings of Tran et al (2015) that no significant differences were observed in fruits wrapped with different colors of bagging materials in terms of fruit size and weight, total soluble solids, and fruit ripening duration among treatments in all three cultivars of dragon fruits.

Table 1. Physical characteristics of dragon fruit.

Treatment	Ave Fruit wt (g)	Ave Fruit Length (mm)	Ave Fruit dm (mm)	Skin Color		
				L	a*	b *
1 (white)	406.00	103.18	83.64	40.05	33.46 [b]	10.71
2 (red)	289.67	94.61	71.08	39.56	40.24 [a]	13.55
3 (blue)	249.33	92.76	70.48	38.89	30.94[b]	10.23
4 green)	373.33	97.40	79.18	42.27	35.14[ab]	10.98

Treatment	Ave Fruit wt (g)	Ave Fruit Length (mm)	Ave Fruit dm (mm)	Skin Color		
				L	a*	b *
5(Control)	242.67	78.15	64.34	39.97	30.93[b]	12.29
Mean	312.20	93.22	73.74	40.15	34.14	11.55
CV(%)	37.67	14.94	15.37	5.72	9.05	12.79

Means with the same letter are not significantly different.

Legend:

(W) – white.

(R) – red.

(B) – Blue.

(G) – Green.

(C) – Control (unwrapped).

Chemical Characteristics of Dragon Fruit

Various chemical parameters are shown in Table 2. Results revealed that fruit bagging significantly affected the electrical conductivity (EC) and vitamin C content of dragon fruit. The EC was significantly higher in fruits wrapped with white-colored cellophane (T_1) with 2.66 mS/cm comparable to red (T_2). However, fruits wrapped with red-colored cellophane which had 2.54 mS/cm are also comparable to fruits wrapped with green (T4) and the control-unwrapped (T5) with both having 2.39 mS/cm of EC. While fruits wrapped with blue-colored bagging material had the lesser EC with only 2.23 mS/cm and therefore a good choice for delaying fruit deterioration.

There are factors affecting the electrical conductivity of agricultural products; electrical conductivity is reported by different authors to be increasing with temperature, field strength, and storage duration until the product is overripe in the case of fruits and vegetables. The decrease in firmness of fruits and vegetables is related to an increase in their conductivity (Banti et al 2020). Looking at the result of the chemical characteristics of dragon fruit in Table 2, fruits wrapped with blue-colored cellophane have the least fruit firmness with only 6.03.

According to Banti et al (2020), electrical conductivity is the ability of a product such as fruit to conduct electric current. This determines the extent of biological changes during its postharvest life. The increase in EC is due to ionic mobility structural changes resulting in structural changes in tissue, like cell wall protopectin breakdown. Hence, an increase in the electrical conductivity of the fruit tissue means a gradual loss of cell membrane integrity (Ahmed et al 2023). Conductivity was also found to decrease with increasing sugar content (Banti et al 2020). In this result, the white bagging color is comparable to red and had the highest EC which would mean that these fruits are prone to early deterioration. Moreover, fruits wrapped with blue cellophane had a higher TSS and a low fruit firmness confirming the findings of Banti (2020).

Meanwhile, the fruits wrapped with white-colored cellophane had the most vitamin C content with 10mg/100

g of dragon fruit comparable to the control (unwrapped) fruits with 8.76 mg/100g and the one wrapped with blue-colored cellophane with 8.09mg/100g of dragon fruit. Fruits wrapped with red-colored cellophane with 7.57mg/100g are comparable to fruits wrapped with blue-colored cellophane and the control with (8.09mg/100 g) and (8.76mg/100g) and the least vitamin C content is fruits wrapped with green-colored cellophane with only 6.57g per 100g of dragon fruit. Vitamin C content in dragon fruit is more than enough to meet the recommended daily allowance (RDA) for men and women aged 19 years old and beyond with 75-90 RDA https://www.health line.com/nutrition/how-much-vitamin-c-should-i-take-daily.

The result of this study is in accordance with the findings of Hossain et al (2023) where maximum vitamin C concentration was recorded in a white paper bag in guava; Meena et al (2016) white poly bag; Kumar et al (2021) in white polythene bags in guava. Similarly, several reports were posted regarding the vitamin C content of dragon fruit, Arivalagan et al (2021) 6 mg/100g; Karunakaran et al (2019) 4-10 mg/100g; Krisanto (2008) 8-9 mg/100g and Rahman et al (2018) with 162.14 mg/100g.

The higher vitamin C content of fruits wrapped with white cellophane could be due to the reflectance of the bagging material. While white contains all the colors in the electromagnetic spectrum, they do not absorb nor transmit light, instead, all are reflected. Therefore, when sunlight (which contains all colors) strikes white materials like cellophane, all the colors of the spectrum are reflected, hence there is no chance that the dragon fruit wrapped with white cellophane receives any photon of light. On the other hand, lower vitamin C content in fruits wrapped with dark-colored cellophane, like blue, red and green could be associated with their light absorbance capacity which is apparently higher than in lighter colors. And since vitamin C is sensitive to air and light (Naidu 2003), it could be degraded by photochemical oxidation (Gallarate et al 1999).

These findings, however, are divergent from the report of Ashrey et al (2020) on pomegranate where ascorbic acid is higher in fruits covered with red-colored bags compared to control, blue and white bags. Shimada and Ko (2008) stated that the oxidation of ascorbic acid by the enzyme ascorbic acid oxidase decreases vitamin-C content. Varied results on vitamin C content could also be dependent on the kind of fruit. Ascorbic acid can easily be altered with high temperatures because it is heat-labile (Yin et al 2022). Selective permeability of colored bags to sunlight may be the probable reason for higher ascorbic acid in red-bagged fruit than in blue color-bagged fruits (Chonhenchob et al 2011). Fruit bagging, however, has no significant effects on other parameters like fruit firmness, % dry matter, juice percentage, fruit volume, TSS, TA, TSS to acid ratio, and pH.

Sensory Characteristics

The sensory characteristics of dragon fruit are shown in Table 3. Results showed that different bagging colors did not significantly affect all the sensory characteristics of dragon fruit. This result is in congruence with the findings of Grinan et al (2018) who found that bagging has no significant effect on the organoleptic attributes of pomegranate. They further stated that no significant effect on sensory qualities is an advantage which means that the internal quality is as good as the control. A different result was presented by Islam et al (2017) on the preharvest bagging of mango. Results revealed that brown paper bags significantly affected the sensory qualities of mango.

Proximate Analysis

The proximate analysis of dragon fruit flesh wrapped with different bagging colors is summarized in Table 4.

The result revealed that dragon fruit wrapped with red-colored cellophane had the highest total N (%) and Mg (mg/kg) content while fruits wrapped with blue-colored cellophane dominated on the total K (mg/kg) and total Ca (mg/kg) content, however, do not bear statistical significance suggesting that bagging has not affected the N, P, K, Ca and Mg content of the fruit. This result is consistent with the observation of Amarante et al (2022) who found no effect on the N, P, K, Ca, and Mg content of pear (Pyrus communis L.) wrapped with micro-perforated polyethylene bags 30 days after full bloom for two consecutive growing seasons.

Table 2. Chemical characteristics of dragon fruit.

Treatment	Fruit Firmness	% DM	% Juice	Fruit Vol (ml)	EC mS/cm	TSS	TA	TSS to Acid Ratio	pH	Vit C mg/100g
1 (W)	6.87	19.95	80.05	245.67	2.66 ^{a}	5.83	7.85	76.63	4.83	10.00 ^{a}
2 (R)	5.63	19.97	80.03	145.33	2.54 ^{ab}	5.63	5.80	100.31	4.70	7.57 ^{bc}
3 (B)	6.03	19.99	80.01	109.33	2.23 ^{c}	7.33	7.08	106.30	4.67	8.09 ^{abc}
4 (G)	6.67	20.00	80.00	210.00	2.39^{bc}	6.87	5.12	136.61	4.70	6.57^{c}
5 (C)	6.33	19.91	80.09	77.67	2.39^{bc}	6.43	6.06	106.12	4.73	8.76 ^{ab}
Mean	6.31	19.96	80.04	157.60	2.44	6.42	6.38	105.19	4.73	8.20
CV (%)	11.05	0.3042	0.0759	70.09	3.54	12.71	16.79	18.40	1.99	12.80

Means with the same letter are not significantly different.

Table 3. Sensory characteristics of dragon fruit.

Treatment	Appearance	Aroma	Taste	Sweetness	Texture/ Mouthfeel
1 (white)	3.44	4.50	4.29	3.84	4.44
2 (red)	4.56	3.96	3.67	3.84	4.11
3 (blue)	4.05	4.05	4.17	4.73	4.51
4 (green)	4.73	3.95	4.06	3.56	4.56
5 (Control)	4.28	4.61 a	4.50	4.51	4.33

Table 4. Proximate analysis of dragon fruit wrapped with different bagging colors.

Treatment	Total N (%)	Total P (%)	Total K (mg/kg)	Total Ca (mg/kg)	Total Mg (mg /kg)
1 (white)	0.67	0.14	20185.25	1733.08	1980.00
2 (red)	0.71	0.14	24598.33	1783.17	2457.75
3 (blue)	0.68	0.14	24926.17	2002.67	2419.58
4 (green)	0.68	0.14	26489.17	1926.83	2361.42

IV. CONCLUSION

Fruit bagging proved to enhance fruit quality. Pre-harvest wrapping of dragon fruit with different bagging co-

-lors significantly affected some of the physico-chemical characteristics of dragon fruit such as skin color, electrical conductivity, and vitamin C content. The fruit bagging materials in red and green colors exhibited a higher degree of red and green color absorption, and the white fruit bagging material got a higher EC and Vitamin C that is comparable to fruits bagged with blue color and the unbagged.

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