Passive Modified Atmosphere Packaging for Low Temperature Storage of White Flesh Variety Dragon Fruit (*Hylocereus undatus* (Haw.) Britton & Rose)

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ABSTRACT

The respiration rate was measured and the required transmission rate was computed at different temperature regimes to determine the compatible thickness of packaging material for dragon fruit. The respiration rates under 10°C and 5°C were determined to be 1.38 mL/kg-h, and 1.08 mL/kg-h, respectively. Polyethylene packaging film with 50.8µm thickness was determined as suitable for MAP of white flesh variety dragon fruit stored at 5°C and 10°C based on the comparison made between the fruit's required transmission rate and film's transmission rate. Actual MAP experiment for 30 days was done to validate the suitability of the selected film. The study shows that weight loss was greater with the controlled samples ranging from 41g to 51g compared to 1.7g to 1.9g of MAP samples. On the other hand, flesh MC was not affected while peel MC of controlled samples significantly decreased by 3.5% to 4.8%. MAP samples' scale color remained green while controlled samples changed from green to yellow. The decrease in the firmness and titratable acidity was delayed for MAP samples while that of controlled samples' decreased by up to 44%. The total soluble solid was not significantly affected by the packaging film. The MAP samples have longer combined storage and shelf life of 25 days compared to controlled samples with 15 days.

Keywords: modified, packaging, dragon fruit, respiration, storage, temperature, transmission, polyethylene, optical, moisture, acidity, firmness

INTRODUCTION

The Philippines is one of the major producers and exporters of tropical fruits. According to FAO statistics as cited by The Report: The Philippines 2012, the country is among the top producers and exporters of several tropical fruits. The Philippine Statistics Authority's Bureau of Agriculture Statistics (PSA-BAS) stated that the production of tropical fruits increased by 1.4% to 12.9% and the production area also increased by 0.2% to 1.8% as compared to data of 2013 (Diega, 2014).

Plans to export some of these fruit products such as banana and mangoes in several United States territories were being negotiated according to the Department of Agriculture - Bureau of Plant Industry (DA-BPI) (DA-OSEC on 2014). This means that it is necessary to increase production further. However, postharvest losses may highly hinder this goal.

Problems in postharvest losses in the country comprise about 35% or US$ 710.4 million annually for fruits and vegetables alone according to Nagpala (2008) of Bureau of Agricultural Research of the Department of Agriculture. About 10% to 50% of the total harvest represents the postharvest losses, thus indicating that up to half of the land, inputs, and labor used to produce the commodities are wasted. Postharvest losses are mainly due to improper handling during harvest, inappropriate packaging, and improper storage temperatures during handling in transit and during storage. With this backdrop, strengthening the postharvest handling ability of the country for fruits and vegetables is needed to decrease the said losses.

Dragon fruit is a tropical fruit that was first introduced in the Philippines in the 1900s. As a non-climacteric fruit, this commodity is usually harvested close to full ripe or mature stage at twenty seven (27) to thirty three (33) days after flowering (DAF) since its quality may suffer otherwise (FAO, 1989). It is tagged by the DA-BAR as a money crop due to its high selling price of US$ 3-4 per kilo in the local market and at an even higher price abroad coupled with low needed investment capital and production maintenance (Reynoso, 2012). At present, this fruit is being produced for local market and is not yet exported. During the Food Congress in Hong Kong, Lorenzo (2010) presented dragon fruit as one of the selected promising fruits to be exported by the Philippines in the future. Among its potential markets include Europe, USA, Canada, Middles East, South and East Asia, Taiwan, and Australia. However, before exporting this product, there is a need to resolve problems related to postharvest handling and processes to achieve the required export quality.

Among the postharvest handling and processes done in addressing these postharvest problems (fast degradation of the fruit's physico-chemical quality, fruit fly infestations and pathogen related problems) are cold storage and disinfestation treatments such as hot water treatment and irradiation but, there are associated problems with these practices. The most common of these type of problems for dragon fruits is chilling injury or frost damage which can cause the wilting (water loss) when being stored below 11 °C (Ortiz-Hernandez and Carrillo-Salazar, 2012 and Paull, 2014). However, the optimum range of temperature for dragon fruit storage is between 5°C to 10°C (Le et al., 2000). With this problem at hand, coming up with a proper storage and packaging systems are necessary. To be able to achieve this goal, a study on the different physiological properties and behavior of the dragon fruits such as respiration rate and transpiration rate under 5 °C and 10 °C storage temperature as well as the characteristics of the storage and packaging materials (gas transmission rate and permeability) to be used is needed.

Identifying these needs, the study focused on determining suitable MAP for white flesh variety dragon fruit using the fruit's respiration rate and required transmission rate in two storage temperatures (5°C and 10 °C). This study also validated the effects of the identified MAP system to the different physico-chemical properties of the fruit.

MATERIALS AND METHODS

Preparation of Sample Materials

Dragon fruits were obtained from a farm in Indang, Cavite, Philippines. Maturity of the fruits was based on the days after flowering (DAF) and samples were harvested at 40 days after flowering (DAF). Samples were washed with water and dried. Samples used during the experiment are free from any visible physical defects (e.g. discoloration, rots, decays etc.). Five (5) dragon fruits (replicates) per treatment were used for the study.

Selection of Suitable MAP

Respiration Rate (RR)

Respiration rate (RR) of the dragon fruit at 5°C and 10°C was determined using static method. A single fruit sample was placed inside a sealed chamber and was left undisturbed during the experiment. The percentage of O_2 and CO_2 inside the chamber were measured using a gas analyzer (PBI Dansensor CheckMate3). Respiration rates were computed at a time wherein O_2 level reaches 3% and from the regression slope of the O_2 concentration versus time. The following equations were used:

$$RR_{O2}\left(\frac{mL}{kg-h}\right) = -\frac{d[O_2]}{dt}\frac{V_f}{100W}$$

where:

$d[O_2]/dt = a_1 b_1 e^{a_1 t}$; V_f = free volume; mL;
W= sample weight, kg

Oxygen Transmission Rate (TrO_2)

The required oxygen transmission rate (TrO_2) was computed using the equation below. The computed TrO_2 was compared to the published data in Malilay et al. (2011). Suitable plastic film thickness for modified atmosphere packaging was selected based on the comparison and analysis made wherein the required transmission rate of the fruit was less than and/or almost equal to the film's transmission rate.

$$RR_{o2}W_f = Tr_{O2}A\frac{[O_2]_e-[O_2]_f}{100}$$

where:

W_f = fill weight (kg);
Tr_{O2} = gas transmission rates (mL/m^2-h);
$[O_2]_e$= ambient gas levels (%);
$[O_2]_f$= desired gas levels (%) in the package headspace;
A = package area (m^2)

Modified Atmosphere Packaging (MAP)

The different physico-chemical properties such as weight loss, moisture content (MC), firmness, peel and scale optical properties, titratable acidity (TA), and total soluble solid (TSS) of the freshly harvested samples were determined.

The selected suitable thickness of low density polyethylene (LDPE) plastic bag was used as packaging material. The fruit was placed and sealed individually into the 7in x 10in plastic bags (MAP samples) and stored at 5°C and 10°C along with the controlled samples. The different physico-chemical properties of the fruits were determined and physical observations for presence of chilling injury were done every five days for 30 days. Headspace gaseous (O_2 and CO_2) composition was measured daily.

Moisture Content (MC)

The peel and flesh of the sample were separated, sliced into small cubes, and weighed. The peel and flesh samples were placed separately in the moisture can with predetermined weight. The samples were then oven dried at 70 °C (Nerd et al., 1999) for 72 hours, final weight was measured, and MC was computed.

Firmness

Firmness of the fruit was determined using a Universal Testing Machine or UTM (Instron 4411). Each of the samples was axially cut into equal half and the cut surface was made the side in contact to the supporting plate of UTM. Each half was compressed slowly with 8 mm cylinder probe to a deformation of 10 mm (ASAE Standards, 1998) at a loading rate of 15 mm/min. The firmness was computed as the slope of the force-deformation curve from zero to the bioyield point.

Peel and Scale Optical Properties

The L* (lightness or brightness) a* (color channel from green to red) b* (color channel from blue to yellow) values of the peel and scale were measured using color meter (Konica Minolta Sensing Inc. CR-10). The measurement was done in any point at the top, middle, and bottom portion of the fruits. The values of L* a* b* were converted to H (hue), S (saturation), and B (brightness) values using the following equations from FAO, 2012:

$$H = tan^{-1}\left(\frac{b^*}{a^*}\right); \quad S = \sqrt{(a^*)^2 + (b^*)^2};$$

$$B = L^*$$

Titratable Acidity (TA) and Total Soluble Solid (TSS)

The fruit flesh was cut into small cubes. Distilled water (60mL) was added to 20g of fruit samples and the mixture was homogenized using a blender. The juice was filtered using cotton and the filtrate was used to determine the TA through manual titration using 0.1N NaOH and TSS through digital refractometer (OPTECH K71601 Model RM45). Malic acid was used as the predominant acid in the TA computation.

Shelf Life

Shelf life was determined by transferring the samples from cold storage to ambient condition for 5 days. The fruits under MAP were removed from the packaging film. Physical observations were done to determine presence of chilling injury and the storage plus shelf life of the fruits.

Statistical Analysis

SAS Software (Version 9.4 licensed to Institute of Statistics UPLB site 12200168; Copyright© 2002-2012 by SAS Institute Inc., Cary, NC, USA) was used for statistical analysis.

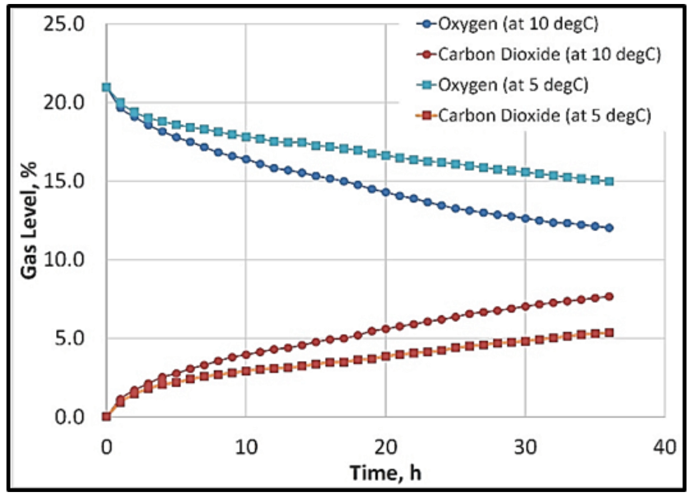

Figure 1. Gas concentration vs. time of dragon fruits in a closed system chamber under ambient, 5°C, and 10° C temperatures

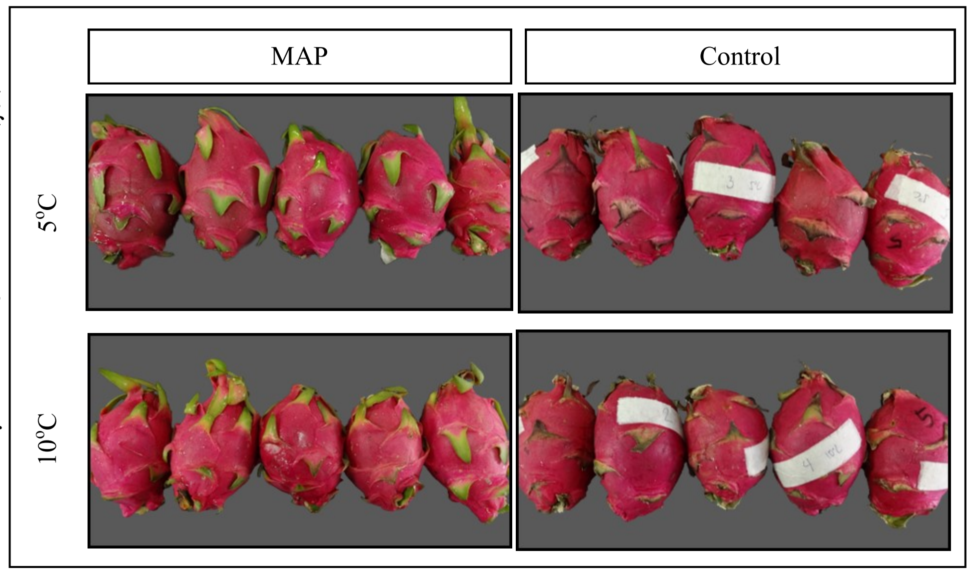

Figure 2. MAP and control samples transferred at ambient temperature (30°C to 32°C) for 5 days after being stored at 5°C and 10°C for 20 days

RESULTS AND DISCUSSION

Respiration Rate (RR)

The O_2 consumption and CO_2 production of the fresh dragon fruits under different temperatures are shown in Figure 1. With $R^2 \geq 0.96$, the equations used for 5°C and 10°C temperature fit well the experimental data. RR of fresh dragon fruits were computed as 1.38 mL/kg-h at 10°C and 1.08 mL/kg-h at 5°C.

Transmission Rate (Tr)

The required TrO2 computed were 1432 mL/m2-day at 5°C and 1838 mL/m2-day at 10°C. These values should be lower and/or almost equal to the published data to avoid anaerobic respiration which can cause off-flavor to the fruit. Result suggests that 50.8µm polyethylene film with 1907 mL/m2-day at 5°C and 2226 mL/m2-day at 10°C (Malilay et al., 2011) resulted to be appropriate for MAP of fresh dragon fruit under 5°C and 10°C temperatures.

Physico-Chemical Properties

Controlled samples and MAP samples at day 20 under 5°C and 10°C temperatures are shown in Figure 2. Physical change in terms of scale color was observed in controlled samples while MAP samples were able to maintain the green scale color. Shrivelling of the scale, a sign of chilling injury according to Nerd et al. (1999) as mentioned by Mizrahi (2014), was observed at day 15 and day 20 for controlled samples at 5°C and 10°C storage temperatures, respectively. This incidence was not observed on MAP samples. On the other hand, occurrence of decays on the stem portion of the fruits was observed for all the samples.

Table 1. Peel and flesh moisture contents (%) and weight change (g) at day 0 and day 30 of dragon fruit under different treatments and storage temperatures

TREATMENT	PEEL MC (%)	FLESH MC (%)	WEIGHT LOSS (g)
Initial	91.962a	87.380a	0.000c
Control at 5°C	88.654b	86.026a	41.180b
Control 10°C	87.506b	86.196a	51.868a
MAP at 5°C	91.314a	87.282a	1.754c
MAP at 10°C	91.192a	87.076a	1.910c

Means with common letter are not significantly different at Tukey's Honest Significance Difference (HSD) at 5%

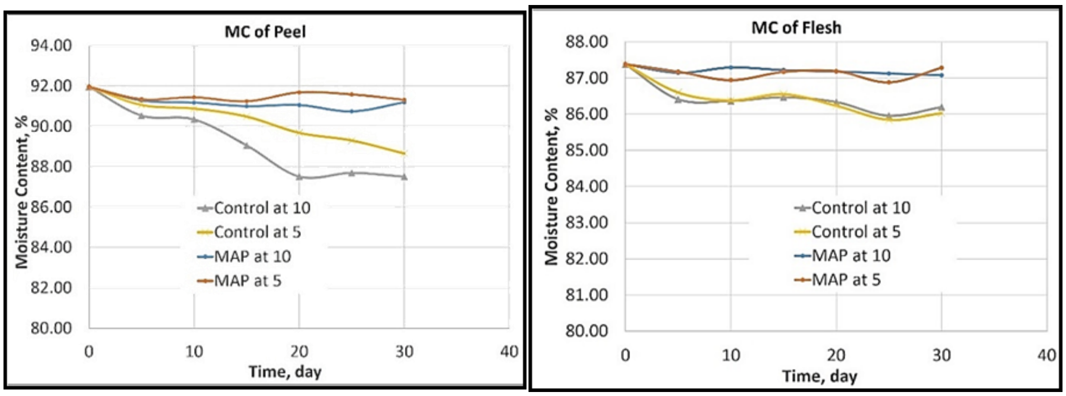

Figure 3. Moisture content of peel (left) and flesh (right) of dragon fruit under 5°C and 10°C storage temperatures

O_2 and Co_2 Composition in Package

Steady state O_2 level readings obtained range from 4.0% to 4.7% at 10°C and from 4.6% to 5.2% at 5° C. These results showed that few adjustments should be done to reach the desired oxygen level of 3% for both temperatures. However, since the system did not reach a dangerous level of O_2 which may trigger anaerobic respiration, the system is appropriate to be used in storing dragon fruits under 5°C and 10°C temperatures.

Moisture Content (MC)

Figure 3 and Table 1 show the peel and flesh moisture content and weight loss of control and MAP samples under 5°C and 10°C storage temperatures. As illustrated, MAP samples have higher MC as compared to control samples. MC of peel for the control samples decreased significantly (p<0.05) from 92% to 88.7% (5°C) and from 92% to 87.5% (10°C) while MC of MAP samples remained within the range of 91% throughout the storage period. In the case of the fruit flesh, MC of control samples slightly decreased from 87% to 86% after day 0 and remained constant at 86% from day 5 to day 30. MC of MAP samples for both temperatures remained 87% throughout the storage period. In Table 1, weight loss of control samples significantly (p<0.05) increased by up to 51g after 30 days in storage.

In a study by Githiga et al. (2014) on the effect of MAP to Tommy Atkins Mango, the same result on the weight loss was observed wherein the unpackaged control samples resulted into significantly higher weight loss as compared to the packaged fruit. The same outcome was also observed in papaya (Jayathunge et al., 2011), hass avocado

(Dixon et al., 2004), green asparagus Techavuthiporn and Boonyaritthongchaib, 2016), carrots (Larsena and Wold, 2016), cherry tomatoes D'Aquino et al., 2016), green chillies (Chitravathi et al., 2015), fresh-cut cilantro (Waghmare and Annapure, 2015), pointed gourd (Sahoo et al., 2015), and Eva apples (Fante et al., 2014).

Weight loss in a commodity is mainly attributed to its continued metabolic processes such as respiration and transpiration after being harvested (Rathore et al., 2007). According to Tano et al. (2008) as mentioned by Chitravathi et al. (2015), respiration causes weight loss because carbon atom is lost from the fruit in each cycle. Transpiration, on the other hand, causes water loss due to the difference in the water vapor pressure between the fruit surface area and the atmosphere (Tzoumaki et al., 2009). Since MAP can maintain higher humidity and retard the respiration rates by reducing the O_2 concentration, it can also minimize weight loss.

Firmness

Firmness of the fruit samples was obtained and the results and statistical analysis are shown in **Figure 4** and **Table 2**. Firmness of samples under MAP decreased by 12% to 13% for both storage temperatures while controlled samples significantly (p<0.05) decreased by 33% (5°C) and 44% (10°C). Firmness started to decrease after being stored for 20 days for samples under MAP and 10 days for controlled samples.

D'Aquino et al. (2016) also reported that firmness was reduced slightly for wrapped cherry tomato samples while unwrapped samples' firmness loss increased greatly. Wrapped samples firmness was higher than those with the unwrapped samples. Previous researches also suggest that MAP is effective in reducing the rate of softening during storage in wide range of fruits such as apricot (Pretel et al., 1993), kiwifruit (Agar et al., 1999), loquat (Amoros et al., 2008), and peaches and nectarines (Akbudak and Eris, 2004) as mentioned by Githiga et al., 2014) and green chillies (Chitravathi et al., 2015), Eva apples (Fante et al., 2014), and Tommy Atkins mango (Githiga et al., 2014).

Nohl (1994) reported that radicals, such as superoxide and nitric oxide that are usually being generated by aerobic respiration, cause cell wall organization to loosen; thus, rendering the wall pectins accessible to pectinases and causing the loss in the firmness during the postharvest life of the produce. Under high CO_2 and low O_2 concentrations, the activities of the cell wall degrading enzymes, such as polygalacturonase were also reduced (Femenia et al., 1998). MAP has the ability to reduce the respiration rate thus leading to reduced rate of firmness loss on fruit samples. In addition, Chitravathi et al. (2015) mentioned that the unpacked fruits or controlled samples lost moisture content faster and became shrivelled leading to faster firmness loss rate as compared to MAP samples.

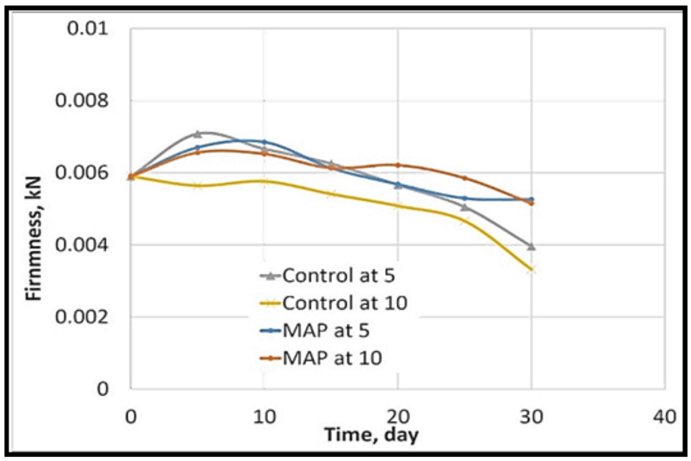

Figure 4. Firmness of dragon fruit samples under5°C and 10°C storage temperature

Table 2. Firmness at day 0 and day 30 of dragon fruit under different treatments and storage temperatures.

TREATMENT	FIRMNESS (kN)
Initial	0.00590a
Control at 5°C	0.00396bc
Control at 10°C	0.00336c
MAP at 5°C	0.00528ab
MAP at 10°C	0.00518ab

Means with common letter are not significantly different at Tukey's Honest Significance Difference (HSD) at 5%

Peel and Scale Optical Properties

The peel and scale color of MAP and controlled samples are shown in Figure 5 and Table 3. The peel hue values for both samples under 5°C and 10°C storage temperatures did not significantly (p>0.05) change with value ranging from 13° to 15°; thus, maintaining its red color. The same result was observed for the saturation value of MAP and controlled samples which ranged from 33% to 36% throughout the storage period. This indicates that the purity and the strength of the peel color were maintained. In terms of brightness, only controlled sample at 5°C significantly (p<0.05) decreased signifying that peel color becomes darker.

Table 3. Optical properties of dragon fruit peel and scale at day 0 and day 30 under different treatments and storage temperatures

SAMPLE	TREATMENT	HUE	SATURATION	BRIGHTNESS
PEEL	Initial	15.058a	33.280a	34.110a
	Control at 5°C	15.798a	35.318a	31.600b
	Control at 10°C	13.330a	33.958a	32.680ab
	MAP at 5°C	14.638a	34.872a	33.080ab
	MAP at 10°C	14.280a	35.094a	33.290a
SCALE	Initial	106.870a	33.744a	46.450a
	Control at 5°C	45.136b	14.392c	31.860b
	Control at 10°C	81.830c	21.818b	39.470a
	MAP at 5°C	101.392a	29.986a	41.780a
	MAP at 10°C	100.122a	32.432a	43.990a

Means with common letter are not significantly different at Tukey's Honest Significance Difference (HSD) at 5%

Scale hue value of MAP samples under both storage temperatures did not significantly (p>0.05) change and instead remained green (ranged from 101° to 107°) throughout the storage period. On the other hand, scale hue value of controlled samples significantly (p<0.05) changed from green (107°) to yellow (55° at 5°C and 81° at 10°C) after 20 days in cold storage. Saturation value was maintained and did not significantly (p>0.05) changed for MAP samples under both temperatures with the value ranging from 29% to 33% at 5°C and 32% to 35% at 10°C. The same result was observed for the brightness value of MAP samples under both temperatures. For controlled samples, saturation value decreased significantly (p<0.05) from 33% to 21% (10°C) and from 33% to 14% (5°C) during storage period. Its brightness value significantly (p<0.05) decreased from 46% to 31% for samples at 5°C.

The results suggested that MAP has the ability to maintain the color of the fruit longer while being stored under low temperature. In addition, lowering the temperature alone will not be able to maintain the green color of the fruit scale throughout the storage period.

Previous studies suggested that the use of packaging materials in storing green chillies was able to maintain the chlorophyll in the fruit longer (up to 28 days) than unpacked samples which only took 15 days (Chitravathi et al., 2015). In a study on green asparagus Techavuthiporn and Boonyaritthongchaib, 2016), a significant loss of chlorophyll was also observed during the storage period of controlled samples at 4°C and after moving them to 10°C as compared with MAP treated samples. Researches on other commodities such as fresh-cut cilantro (Waghmare and Annapure, 2015) and Tommy Atkins mango (Githiga et al., 2014) were also suggesting similar result in terms of color retention during storage.

According to Chitravathi et al. (2015), the retention of the green pigment may be due to slower chlorophyll degradation or breakdown rate and the decrease in the rate of anthocyanins and carotenoids biosynthesis, (occurring during senescence) as a result of lowering the O_2 and elevating the CO_2 or retarding the respiration rate which occurred during MAP. Lowering the O_2 level also reduces ethylene biosynthesis; thus, reducing the activities of enzymes, such as chlorophyll oxidase involved in color changes during ripening (Githiga et al., 2014).

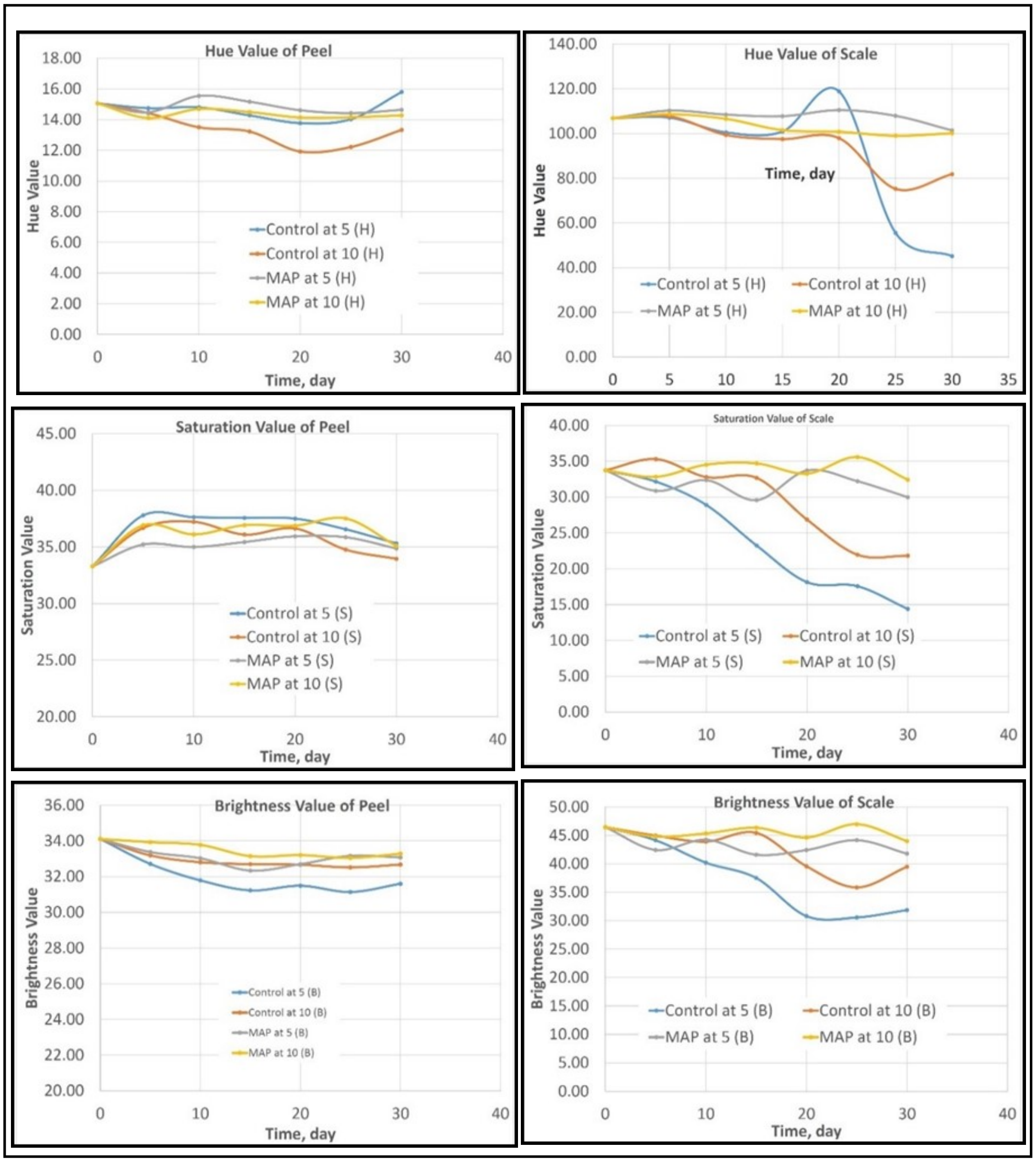

Figure 5. Plotted H-S-B readings of the peel (left) and scale (right) of MAP and controlled samples under 5°C and 10°C storage temperatures

Titratable Acidity (TA)

Figure 6 and **Table 4** show the measured titratable acidity (TA) and statistical analysis results. Observations suggest that the decrease rate in TA of MAP samples was slower than the controlled samples. Higher TA of samples at 5°C than at 10°C suggests that lower temperature results in TA retention in the fruits. TA value of MAP samples at 5°C and 10°C and controlled samples at 5°C which decreased by 13.3%, 26.7%, and 23.3%, respectively were not significantly ($p > 0.05$) different with the TA of fresh samples. Controlled samples at 10°C decreased significantly ($p < 0.05$) by 46.7%.

In green asparagus, MAP exhibited ascorbic acid retention throughout the experimentperiod (Techavuthiporn and Boon-yaritthongchaib, 2016). Similar result was reported by Githiga et al. (2014), wherein the packaged fruits were able to retain higher TTA or percentage citric acid as compared to controlled samples throughout the storage period. Researches on the MAP of dragon fruits by de Freitas and Mitcham (2013) and strawberry by Almenar et al. (2008) have also shown similar trend. De Freitas and Mitcham (2013) also mentioned that the delay in the decrease of TA was also due to lower temperature.

Major organic acids found in the fruits and other fresh produce are mainly used as a substrate during respiration (Lizada 1993, Githiga et al., 2014). Thus, reducing the rate of respiration by lowering the O_2 level and temperature will slow down the consumption of these substrates; hence, reducing the rate of decrease in TTA and retaining higher value up to the end of storage period (Githiga et al., 2014).

Total Soluble Solid (TSS)

The measured TSS values are shown in Figure 7 and Table 4. TSS significantly ($p<0.05$) decreased for controlled samples at 5°C and 10°C and MAP samples at 10°C from 10.8°Brix (initial value) to 9.2°Brix, 9.09°Brix, and 9.1°Brix, respectively. MAP samples at 5°C did differ significantly with the initial value. Observation suggests that lower storage temperature has the ability to maintain the TSS of the fruits.

Techavuthiporn and Boonyaritthongchaib (2016) reported that using MAP preserves the total sugar content of green asparagus as compared to unpackaged samples. This result is also similar with a recent study on Tommy Atkins mango (Githiga et al., 2014). However, in the case of dragon fruit, as reported by de Freitas and Mitcham (2013), there was no change in TSS content during storage plus shelf life. According to the study, the use of packaging materials has no effect on the TSS of the samples. In addition, low temperature may be responsible in the retention of the TSS in the fruit (Punitha et al., 2010) since lowering the temperature resulted in lower respiration rate; hence there is a decrease in the amount of substrate such as sugar and protein being used during respiration. This tends to retain the TSS of the fruit samples in storage.

Shelf Life

MAP and controlled samples, after being exposed for 5 days at ambient conditions, are shown in Figure 8. MAP samples stored for 20 days under both temperatures were still acceptable in appearance after exposing it under ambient conditions for 5 days. Controlled samples stored for 15 days under both temperatures started to manifest peel deterioration after being stored to normal conditions. According to Nerd et al. (1999) as mentioned by Paull (2014), this peel deterioration is a sign of chilling injury. These results suggest that MAP samples tend to have longer storage plus shelf life of 25 days without undergoing chilling injury for both temperatures as compared to controlled samples' 15 days.

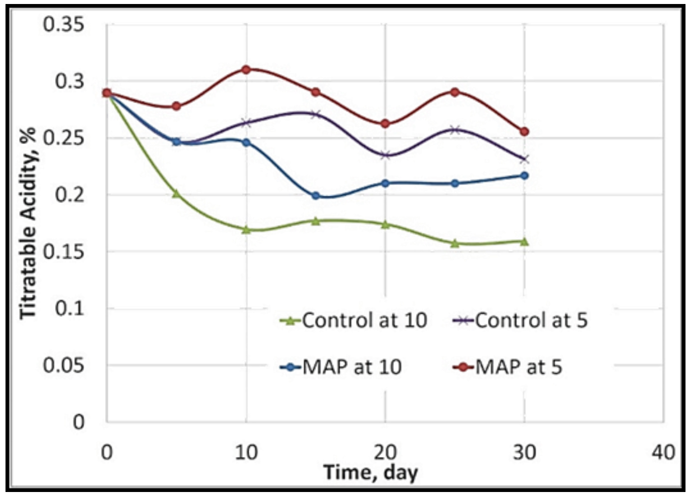

Figure 6. Titratable acidity of MAP and controlled samples at 5 and 10 storage temperatures

Table 4.TA (%) and TSS (°Brix) at day 0 and day 30 of dragon fruit under different treatments and storage temperatures

TREATMENT	TA (%)	TSS (°Brix)
Initial	0.290a	10.816a
Control at 5°C	0.232ab	9.2480b
Control at 10°C	0.160b	9.0880b
MAP at 5°C	0.258a	9.5360ab
MAP at 10°C	0.220ab	9.1360b

Means with common letter are not significantly different at Tukey's Honest Significance Difference (HSD) at 5%

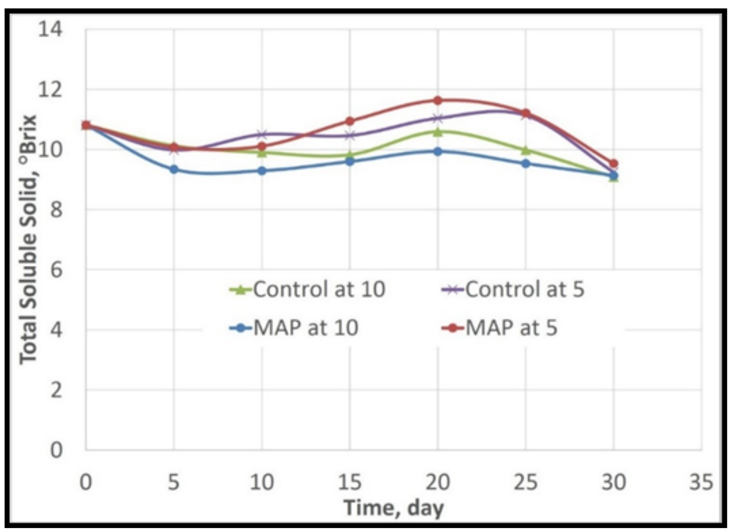

Figure 7. Total soluble solid of MAP and controlled samples at 5°C and 10°C storage temperatures

CONCLUSION

MAP using the proper thickness of polyethylene film was able to avoid the occurrence of anaerobic respiration inside the packaging (balance fruit respiration rate and gas transmission rate of plastic film) and scale shrivelling of dragon fruits (sign of chilling injury). It was also able to maintain or slow down the degradation of several physico-chemical properties of the white flesh variety dragon fruits under low storage temperatures of 5°C and 10°C. Among these physical and chemical properties include weight, MC, firmness, scale and peel color and TA. Using packaging did not affect the value of TSS of the fruits. The TSS value remained constant for all the treatments. Longer storage plus shelf life of 25 days, without undergoing chilling injury, was also observed for the packaged fruits.

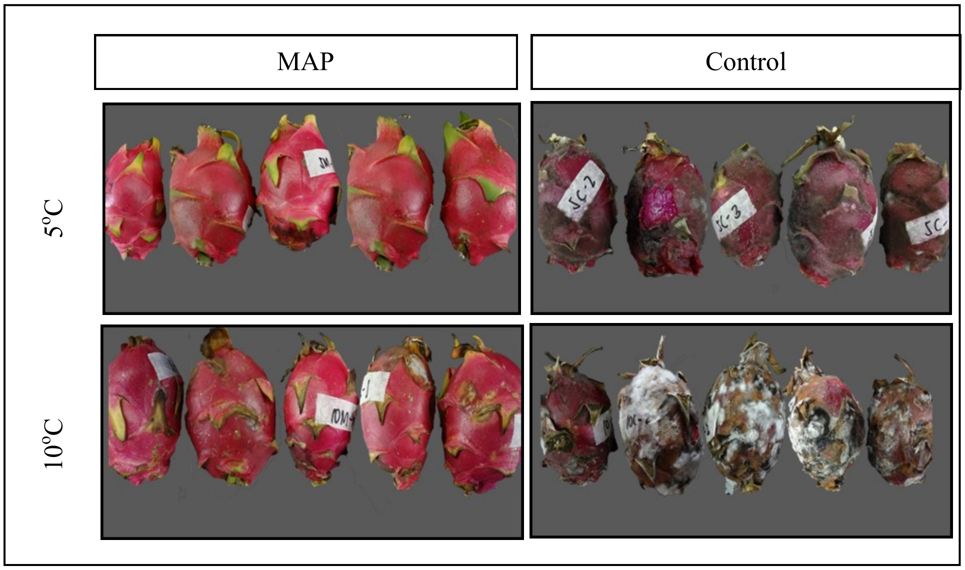

Figure 8. MAP and control samples transferred at ambient temperature (30°C to 32°C) for 5 days after being stored at 5°C and 10°C for 20 days

Comparing the two storage temperatures, result showed that 5°C storage temperature was better than 10°C. Dragon fruits stored at 5°C manifested lower weight loss and TA and TSS reduction rates.

RECOMMENDATIONS

Based on the results of the study, the following recommendations can be adapted in the future:

1. Smaller area of LDPE packaging film may be used for smaller size dragon fruits. However, this size reduction may or may not affect the suitable thickness of the packaging film.
2. Sensory evaluation of the dragon fruits should be done after the storage period to identify the consumer's acceptability of the product.
3. Similar study can be extended to other equally-exportable varieties of dragon fruit.

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