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Controlling the Spread of Ethylene through the Introduction of Modified Evaporative Cooler in Extending Shelf Life and Quality of Fruits

Cynthia Sarmiento Alvez

cynthiaalvez144[at]gmail.com

Abstract: ***An experiment conducted to study the effects of storage conditions of Red Lady papaya fruits at different maturity stages. The experiment used Completely Randomized Design (CRD) with 3 replications and 3 treatments. The treatments were designated as follows: T1 – Start of yellowing to ½ inch length of yellow; T2 – More than ½ inch length to 1 inch length of yellow; T3 – More than 1 inch length to 1.5 inches length of yellow; and storage conditions: Ambient; High Humidity (EC) and Refrigerator. Data were analyzed using Sheff's Test (HSD). Results showed that Red Lady papaya fruits can be stored longer in refrigerator than in ambient or EC conditions. Significant results were attained on peel yellowing, sensory firmness, and sensory evaluation on taste, sweetness, juiciness, weight loss, and visual quality of fruits***

Keywords: firmness, maturity, storage, sensory, quality, fruits, organoleptic attributes

1. Introduction

Storage of fresh horticultural produce after harvest is one of the most pressing problems of a tropical country. Due to its high moisture content, fruits and vegetables has a very short life and are liable to spoil. Moreover, they are living entities and carry out transpiration, respiration and ripening even after harvest. Metabolism in fresh horticultural produce continues even after harvest and the deterioration rate increases due to ripening, senescence and unfavourable environmental factors. Fruits and vegetables are highly perishable commodities that cannot be kept for long period of time due to their perishable and seasonal nature. It is therefore important that they are preserved in seasons.

The fruits and vegetables, being perishable, need immediate post harvest attention to reduce the microbial load and increase their shelf life, which can be achieved by storing them at low temperature and high relative humidity conditions. These conditions are usually achieved in cold storages. Evaporative cooling is an efficient and economical means for reducing temperature and increasing the relative humidity of an enclosure, and has been extensively tried for enhancing the shelf life of horticultural produce (Jha and Chopra 2006; Dadhich et al. 2008; Odesola and Onyebuchi 2009) which is essential for maintaining the freshness of the commodities (Dadhich et al. 2008). Hence, preserving these types of foods in their fresh form demands that the chemical, bio - chemical and physiological changes are restricted to a minimum by close control of space temperature and humidity (Chandra et al. 1999).

The perishability of the fruit is the main problem in the market since most vendor has no postharvest equipment used. The "Red Lady" papaya is an improved, high quality variety with reddish - orange flesh. The Red Lady cultivar represents a major proportion of exported papayas (Lucknow, 2000). Maturity at harvest is an important factor affecting quality perception and the rate of change of quality during postharvest handling. Maturity indices can be determined in many ways including estimation of the duration of development; measurement of sizes, weight, or density; physical attributes such as color, firmness and moisture or solid content; other chemical attributes such as starch, sugar or acid content; or morphological evaluation. Harvest time also has an influence on fruit sensorial quality. Postharvest physiology can be affected by cultivar, environmental conditions and also by harvest time. Harvest time is fundamental to obtain a high - quality fruit with storage potential (Serry, 2010). Evaporative cooling is an environmentally friendly air conditioning system that operates using induced processes of heat and mass transfer where water and air are working fluids (Camargo 2007). Such a system provides an inexpensive, energy efficient, environmentally benign (not requiring ozone - damaging gas as in active systems) and potentially attractive cooling system (Zahra and John 1996).

Fruit blends present a series of advantages, such as the possibility of combining different aromas and flavors, plus the sum of nutritionally different components. Sensory attributes of papaya include pulp color, taste, aroma, off – odor, off flavor, sweetness, juiciness, and over - all acceptability. This attribute was the main significance in determining the quality of the fruits in relation to its marketing and satisfaction of consumers. Shelf life of a commodity is governed by several factors e. g. variety, stage of maturity, rate of cooling, storage temperature, relative humidity, packaging system, etc. It is important to keep in mind that they usually interact with each other to influence the overall rate of evaporation, and therefore, the rate and event of cooling. Storage temperatures and relative humidity affect the storage losses to a great extent. Proper control of temperature and relative humidity is the key to prolong the storage life and marketable quality. Thus, at high relative humidity, produce maintains its saleable weight, appearance, nutritional quality and flavor, while wilting, softening and juiciness are reduced.

2. Objectives of the Study

The study generally aimed to determine the postharvest

characteristics of 'Red Lady' papaya fruits at different maturity stages and storage conditions. More specifically, the study aimed to:

1) Determine the effects of evaporative cooler storage on Red Lady papaya fruits harvested at different maturity stages or ripeness.
2) Evaluate the effectiveness on the ripening of papaya as influenced by storage conditions.
3) Evaluate the organoleptic attributes of papaya in terms of taste, aroma, pulp color, juiciness, sweetness and over - all acceptability of consumer.

3. Theoretical Framework

4. Materials and Methods

Place and Time of Study
The study was conducted at University of Southeastern Philippines – Tagum Campus, Apokon, Tagum Cityon June, 2015 to June, 2016 at the Food Technology Laboratory of the university.

Fruit Sampling
Sampling of fruits was done by purchasing the ripen fruits at different level of ripeness from harvesting. The fruits were sampled and set by levels of ripeness as the designated treatments. Setting of fruits for sensory is being prepared and cleaned prior to testing by evaluators.

Treatments:
Stages of Maturity
T1 – Start of yellowing to ½ inch length of yellow
T2 – More than ½ inch length to 1 inch length of yellow
T3 – More than 1 inch length to 1.5 inches length of yellow

Storage Conditions
S1 – Ambient
S2 – High Humidity (EC)
S3 – Refrigerator

Peel color index.
The peel color changes in each fruit sample were assessed daily using the following color index (CI): (Instron, Norwood, and Zou, et al., 2014)

CI Description
1) Green skin without yellow stripe, fully green
2) Green skin or breaker, not more than 10% yellow
3) Green skin with well - defined yellow stripe
4) One or more orange–colored stripes in skin
5) Clearly orange–colored skin with some light green areas
6) Characteristic orange- colored skin, fully yellow
7) Fruit color similar to stage 6 but more intense

Sensory Firmness
The sensory firmness was determined by peel method, using the following index

Index Description
1) Firm or hard
2) First perceptible softening
3) Moderately soft
4) Ripe soft

Preparation of Score sheet
Score sheets were properly prepared and reproduced for the actual sensory activity. Evaluators rated the fruits based on the characteristics it shows as to pulp color, sweetness, aroma, taste, off - odor, off - flavor and juiciness.

Organoleptic attributes
The sensory attributes such as pulp color, taste, aroma, off - odor (alcoholic), off - flavor (alcoholic), and overall acceptability at sensory firmness 4 were measured. Each sensory attribute was assessed by a panel of 15 evaluators on a 10 cm line.

Data Collection

Organoleptic attributes of the fruits

1) **Pulp color**
Peel color of Red Lady Papaya at ripen stage turns fully yellow and rated based on the scale of the score sheet provided.
2) **Taste**
Taste of the fruits weredetermined by the evaluators preference using the score sheet provided and indicate the score by placing a marks.
3) **Aroma**
The aroma of the Red Lady Papaya was rated according to the evaluators preference of evaluation of its smell using the score sheet.
4) **Off - Flavor**
The off - flavor of the Red Lady papaya was rated on the degree of its flavor during the evaluation of its sensory attributes using the score sheet.
5) **Off – odor**
Off - odor of the fruits were evaluated and rated during its ripe stage on the level of its odor or smell using the score sheet provided
6) **Sweetness**
The level of sweetness of the fruits were evaluated and rated using the score sheet during its ripe stage.
7) **Juiciness**
The juiciness of the fruits were rated and evaluated based on the degree of water content of the fruit during its ripen stage using the score sheet evaluation form.
8) **Over - all acceptability**
The over - acceptability of the product was evaluated and rated based on its appearance for marketing purposes and consumption using the score sheet evaluation.

Statistical Analysis
The data were analyzed using ANOVA in two factorial experiments in Completely Randomized Design (CRD). Treatment means of significant results were analyzed using Honest Significant Difference Test (HSD) or Sheffe's Test.

5. Results and Discussion

Peel Yellowing
Papaya is a climacteric fleshy fruit that undergoes dramatic changes during ripening, most noticeably a severe pulp softening. Papaya fruits were stored at ambient, EC and refrigerator storage conditions. Among storage conditions,

significant differences on the peel yellowing of the fruits were observed after 3 days of storage and onwards (Table 1.0).

As expected, refrigerated conditions significantly retarded the peel color change of the fruits as indicator of ripening than ambient and EC storage. However, peel color changes in fruits stored at ambient and EC did not differ significantly. Fruits stored at refrigerator (9.90°C) then transferred to ambient conditions after 8 days showed a rapid peel yellowing development.

On the stage of ripeness, significant differences were observed among treatments on the first day of storage to 12th day while on the 13th day onwards, comparable results were observed. The fastest yellowing of fruits of ½ - 1 inch yellow and 1 inch to 1.5 inches yellow from the tip of the fruit was attributed to the initial degree of ripening at the start of experiment as consideration in the treatments. Peel yellowing on fruits harvested with less than ½ inch length of yellow and fruits harvested with more than ½ inch to1 inch showed the same degree of yellowing after 6 days of storage.

On the interaction between storage and stage of ripeness, significant differences were observed up to 12 days of storage. As expected, fruits stored in refrigerated conditions harvested at less degree of yellowing showed slower yellowing development during storage among treatment combinations. On the other hand, comparable results were obtained on the peel yellowing of fruits stored at ambient and EC at any stage of ripeness.

Results implied that refrigerated conditions retard the peel yellowing of fruits due to low temperature, reduced oxygenand carbon dioxide more than in EC and ambient storage. Moreover, Kader (1986) pointed out that lowering oxygen and/or elevating carbon dioxide levels around the fresh fruits and vegetables reduces the respiration rate and retards ripening. Fruits during storage proceed to a rapid change in metabolic processes. The breakdown of the cell wall and structures that is brought by such a process goes on with a continued state of changes including ripening and deterioration of quality. During this process, a fruit gradually converts starch to sugar which is one of the attributes of fruit associated with ripening. Results conformed to the findings ofBrummel et al. (2006) that several major changes take place as the fruit ripens and these characterize fruit ripening collectively such as changes in carbohydrate composition, which results in sugar accumulation and increased sweetness, change in color, flesh softening and textural change, formation of aroma volatiles and accumulations of organic acids associated with development of flavor of the fruits.

Table 1: Peel yellowing on Red Lady papaya fruit at different storage conditions and stages of maturity

Treatment	Days of Storage														
Storage Condition (A)	1^{ns}	2^{ns}	3^{*}	4^{**}	5^{**}	6^{**}	7^{**}	8^{**}	9^{**}	10^{**}	11^{**}	12^{**}	13^{**}	14^{ns}	15^{ns}
Ambient	2.5	3.00	3.57^{b}	4.02^{a}	4.30^{c}	4.96^{b}	5.20^{b}	5.31^{b}	5.39^{b}	5.39^{b}	5.44^{b}	5.46^{b}	5.46^{ab}	5.46^{a}	5.46^{a}
Evaporative Cooler	2.5	3.00	3.48^{b}	3.76^{b}	4.02^{b}	4.59^{b}	5.06^{b}	5.74^{b}	5.87^{b}	5.87^{b}	5.87^{b}	5.87^{b}	5.87^{b}	5.87^{b}	5.87^{b}
Refrigerator	2.4	2.72	2.74^{a}	2.76^{a}	2.80^{a}	2.80^{a}	2.85^{a}	3.02^{a}	3.11^{a}	3.17^{a}	3.41^{a}	4.37^{a}	5.35^{a}	5.65^{ab}	5.72^{ab}
Stages of Maturity (B)	1^{**}	2^{**}	3^{*}	4^{**}	5^{**}	6^{**}	7^{**}	8^{**}			11^{**}	12^{**}	13^{ns}	14^{ns}	15^{ns}
Start yellowing - 1/2 inch yellow	2.00^{a}	2.22^{a}	2.69^{a}	2.85^{a}	3.07^{a}	3.48^{a}	3.81^{a}	4.31a	4.44^{a}	4.44^{a}	4.56^{a}	4.94^{a}	5.35	5.57	5.61
1/2 - 1 inches yellow	2.35^{b}	2.85^{b}	3.11^{b}	3.41^{b}	3.56^{b}	3.98^{b}	4.20^{a}	4.57^{a}	4.67^{a}	4.70^{a}	4.81^{ab}	5.19^{ab}	5.57	5.63	5.67
1 - 1.5 inches yellow	3.06^{c}	3.65^{c}	4.00^{c}	4.28^{c}	4.48^{c}	4.89^{b}	5.09^{b}	5.19^{b}	5.26^{b}	5.28^{b}	5.35^{c}	5.57^{b}	5.76	5.78	5.78

[1]Data based on the average of 6 fruits/treatments/replicate
[2]Ambient (ºC, RH, VPD), EC (ºC, RH, VPD), Refrigerator (ºC, RH, VPD)
[3]0.5 inch yellow from the tip, 0.5 - 1 inch yellow from the tip, 1 - 1.5 inches yellow from the tip
^{ns} Not Significant
** Highly Significant at 1% level
* Significant at 5% level

Table 1.1: Interaction effect on peel yellowing of Red Lady papaya fruitat different storage conditions and stages of maturity

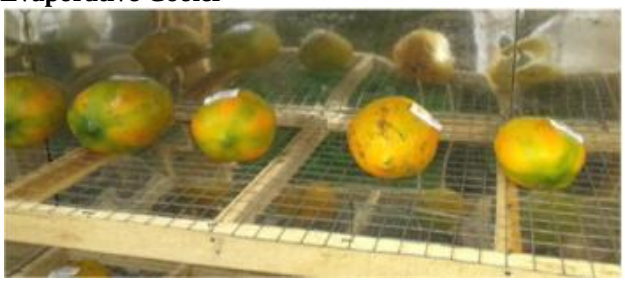
Treatments	Days of Storage														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ambient															
Start yellowing - 1/2 inch yellow	2.0^{a}	2.3^{ab}	3.2	3.4	3.8	4.7	5.2^{cde}	5.3^{cd}	5.3^{cd}	5.3	5.4^{c}	5.4	5.4	5.4	5.4
1/2 - 1 inches yellow	2.4^{ab}	2.9^{abc}	3.3	3.8	4.0	4.5	4.7^{cde}	4.9^{cd}	5.2^{cd}	5.2	5.2^{c}	5.2	5.2	5.2	5.2
1 - 1.5 inches yellow	3.1^{b}	3.8^{c}	4.2	4.8	5.1	5.7	5.7^{e}	5.7^{d}	5.7^{cd}	5.7	5.7^{c}	5.7	5.7	5.7	5.7
Evaporative Cooler															
Start yellowing - 1/2 inch yellow	2.0^{a}	2.3^{ab}	2.8	3.1	3.4	3.7	4.2^{cd}	5.4^{cd}	5.7^{d}	5.7	5.7^{c}	5.7	5.7	5.7	5.7
1/2 - 1 inches yellow	2.6^{ab}	3.2^{bc}	3.6	3.9	4.1	4.9	5.4^{de}	6.0^{d}	6.0^{d}	6.0	6.0^{c}	6.0	6.0	6.0	6.0
1 - 1.5 inches yellow	2.9^{b}	3.4^{c}	4.1	4.3	4.6	5.2	5.6^{e}	5.8^{d}	5.9^{d}	5.9	5.9^{c}	5.9	5.9	5.9	5.9
Refrigerator															
Start yellowing - 1/2 inch yellow	2.0^{a}	2.1^{a}	2.1	2.1	2.1	2.1	2.1^{a}	2.3^{a}	2.3^{a}	2.3	2.6^{a}	3.7	4.9	5.6	5.7
1/2 - 1 inches yellow	2.0^{a}	2.4^{ab}	2.4	2.5	2.6	2.6	2.6^{ab}	2.8^{ab}	2.8^{ab}	2.9	3.2^{ab}	4.3	5.5	5.7	5.8
1 - 1.5 inches yellow	3.2^{b}	3.7^{c}	3.7	3.7	3.8	3.8	3.9^{bc}	4.0^{bc}	4.2^{bc}	4.2	4.4^{bc}	5.1	5.7	5.7	5.7

CV	1.62	4.17	3.02	1.70	1.64	1.79	2.02	1.68	1.72	1.77	2.10	3.66	8.82	9.56	20.48
LSD	*	*	NS	NS	NS	NS	**	*	**	NS	*	NS	NS	NS	NS

[1]Data based on the average of 6 fruits/treatments/replicate
[2]Ambient (ºC, RH, VPD), EC (ºC, RH, VPD), Refrigerator (ºC, RH, VPD)
[3]0.5 inch yellow from the tip, 0.5 - 1 inch yellow from the tip, 1 - 1.5 inches yellow from the tip
[ns] Not Significant
[**] Highly Significant at 1% level
[*] Significant at 5% level

Ambient

Evaporative Cooler



Refrigerator

Figure 1: Peel yellowing on Red Lady papaya fruitsstored at ambient, EC and refrigerator storage conditions. Ambient stored fruits attained full yellow at 6 - 7 days, EC 8 - 10 days and refrigerated fruits 14 - 15 days but with uneven yellow color after it was placed in ambient conditions

Sensory Firmness

Sensory firmness of the fruits at different storage conditions and maturitystages is presented in Table 4.0 and 4.1. Fruit softening was observed at the 3rd day of storage. Storage conditions significantly affect the softening of the fruits. Significant difference was observed on fruit softening among storage conditions up to the 9th day of storage. Softening of fruits stored at refrigerated condition was delayed than in EC and ambient stored fruits which was observed at 8th days of storage. Softening of fruits stored at EC and ambient were comparable starting on the 13th day of storage.

On the different maturity stages, more mature fruits at harvest also resulted in faster softening development which was evident after the 3rd day of storage up to the 7th day of storage. However, softening of fruits at different maturity stages was comparable from the 8thday of storage onwards.

On the interaction effect, fruits stored at refrigerated condition regardless of the degree of maturity remained firm for a longer period of time than ambient and EC stored fruits at different degrees of maturity. Firmness was maintained while stored in the refrigerator due to the low temperature, low oxygen and carbon dioxide. However, on the 8th day of storage after being taken out from the refrigerator and placed in ambient conditions, a rapid metabolic process occurred and softening of the fruit was observed.

These results confirmed the findings of Bautista in 2007 that the process of softening is a consequence of the collapse cell walls and breakdown of pectins and starch into simpler forms. The difference on fruit firmness among the maturity stages may vary in their pectin composition and causes rapid softening during storage. The higher rate of firmness at refrigerated condition is due to the intact cell structure and turgidity as an indicator of fruit firmness. Low temperature, low oxygen and carbon dioxide concentration and less transpiration rate causes also the firmness of the fruit. The results also support the findings of Fuller in 2008 that the firmness of the fruit depends on the texture of the flesh and changes in primary cell wall during ripening. All fruits soften as they ripen due to changes in cell wall composition and structure (https//: Books. google. com. ph).

Table 2: Sensory firmness on Red Lady papaya fruit at different storage conditions and stages of maturity

Treatment	Days of Storage														
Storage Condition (A)	1^{ns}	2^{ns}	3*	4^{**}	5^{**}	6^{**}	7^{**}	8^{**}	9^{**}	10^{**}	11^{**}	12^{**}	13^{**}	14^{ns}	15^{ns}
Ambient	1.00	1.00	1.20^{b}	1.63^{c}	1.79^{c}	2.28^{c}	2.98^{c}	3.50^{c}	3.72^{c}	3.80^{b}	3.80^{b}	3.80^{b}	3.80^{b}	3.80	3.80
Evaporative Cooler	1.00	1.00	1.06^{ab}	1.31^{b}	1.43^{b}	1.61^{b}	2.35^{b}	2.80^{b}	3.35^{b}	3.74^{b}	3.89^{b}	3.89^{b}	3.93^{b}	3.93	3.93
Refrigerator	1.00	1.00	1.00^{a}	1.00^{a}	1.00^{a}	1.00^{a}	1.00^{a}	1.02^{a}	1.09^{a}	1.20^{a}	1.72^{a}	2.56^{a}	3.35^{a}	3.98	4.00
Stages of Maturity (B)	1^{ns}	2^{ns}	3^{ns}	4^{**}	5^{**}	6^{**}	7^{**}	8^{ns}	9^{ns}	10^{ns}	11^{ns}	12^{ns}	13^{ns}	14^{ns}	15^{ns}
Start yellowing - 1/2 inch yellow	1.00	1.00	1.04	1.09^{a}	1.13^{a}	1.41^{a}	1.87^{a}	2.33	2.70	3.00	3.20	3.52	3.80	3.93	3.93

1/2 - 1 inches yellow	1.00	1.00	1.04	1.28[a]	1.33[b]	1.56[b]	2.07[ab]	2.46	2.80	2.93	3.17	3.43	3.69	3.69	3.93
1 - 1.5 inches yellow	1.00	1.00	1.19	1.57[b]	1.76[c]	1.93[c]	2.39[c]	2.52	2.67	2.81	3.04	3.30	3.59	3.81	3.81

[1]Data based on the average of 6 fruits/treatments/replicate
[2]Ambient (ºC, RH, VPD), EC (ºC, RH, VPD), Refrigerator (ºC, RH, VPD)
[3]0.5 inch yellow from the tip, 0.5 - 1 inch yellow from the tip, 1 - 1.5 inches yellow from the tip
[ns] Not Significant
[**] Highly Significant at 1% level
[*] Significant at 5% level

Table 2.1: Interaction effect on sensory firmness of Red Lady papaya fruit at different storage conditions and stages of maturity

Treatment	Days of Storage														
Ambient	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Start yellowing - 1/2 inch yellow	1	1	1.1	1.3[b]	1.4[ab]	1.9[b]	2.4	3.2	3.6	3.8	3.8	3.8	3.8	3.8	3.8
1/2 - 1 inches yellow	1	1	1.1	1.5[ab]	1.5[ab]	2.1[ab]	2.9	3.7	3.9	3.9	3.9	3.9	3.9	3.9	3.9
1 - 1.5 inches yellow	1	1	1.4	2.1[c]	2.5[a]	2.8[c]	3.6	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Evaporative Cooler															
Start yellowing - 1/2 inch yellow	1	1	1	1.0[a]	1.0[a]	1.3[ab]	2.2	2.8	3.4	3.8	4	4	4	4	4
1/2 - 1 inches yellow	1	1	1.1	1.3[b]	1.5[ab]	1.6[ab]	2.3	2.7	3.4	3.8	4	4	4	4	4
1 - 1.5 inches yellow	1	1	1.1	1.6[ab]	1.8 [b]	1.9[b]	2.6	2.9	3.2	3.6	3.7	3.7	3.8	3.8	3.8
Refrigerator															
Start yellowing - 1/2 inch yellow	1	1	1	1.0[a]	1.0[a]	1.0[a]	1	1.1	1.1	1.4	1.8	2.8	3.6	4	4
1/2 - 1 inches yellow	1	1	1	1.0[a]	1.0[a]	1.0[a]	1	1	1	1	1.6	2.3	3.1	3.9	4
1 - 1.5 inches yellow	1	1	1	1.0[a]	1.0[a]	1.0[a]	1	1	1.2	1.2	1.8	2.6	3.3	4	4
CV	0	0	1.70	2.00	2.27	1.36	1.04	0.57	0.49	8.11	0.97	2.61	10.04	16.98	13.73
LSD	ns	ns	ns	**	**	**	ns	ns	ns	ns	ns	ns	ns	ns	ns

[1]Data based on the average of 6 fruits/treatments/replicate
[2]Ambient (ºC, RH, VPD), EC (ºC, RH, VPD), Refrigerator (ºC, RH, VPD)
[3]0.5 - inch yellow from the tip, 0.5 - 1 - inch yellow from the tip, 1 - 1.5 inches yellow from the tip
[ns] Not Significant
[**] Highly Significant at 1% level
[*] Significant at 5% level

Organoleptic attributes

The organoleptic attributes (Sensory evaluation) of the sampled fruits is shown in Table 3.0 and 3.1. Results revealed that on peel or pulp color, off - odor, off - flavor, and juiciness of the fruits significantly differed among storage conditions. Fruits stored at EC were observed with lower juice content and with more distinct off - flavor and off–odor than ambient and refrigerated stored fruits. Other sensory attributes of the fruits were comparable among storage conditions.

On the maturity stages of the fruits, significant results were observed on all sensory attributes. Fruits harvested at more mature were characterized with more peel yellowing and obtained better sensory attributes than fruits harvested with less yellow.

On the interaction effects, significant differences were observed on pulp color, aroma and taste. Refrigerated stored fruits at more mature stage obtained the highest pulp color than in EC and ambient conditions because they had advanced yellow color at harvest, while aromas were observed in good quality in refrigerated stored fruits harvested at more mature than in less mature fruits.

On the other hand, taste of the fruits significantly differed in refrigerated conditions than in EC and ambient at more matured fruits. Good sensory attributes were observed in refrigerated conditions more than in EC and ambient conditions but could not be stored longer. Results conform to the findings of Cano et al., 1996 that during the ripening process, the nutritional content of papaya alters mostly because of carotenoids synthesis which reaches elevated levels during normal ripening. It is evident that all varieties are produced and stored to maintain the very best flavor and aroma properties. As indicated by Brummel in 2006, there are two main factors that determine fruit's characteristic flavor: the correct sugar and acid content balance and the production of aroma volatile compounds (volatile acids, aldehydes, alcohols, esters, terpenoids and aromatics).

Table 3: Organoleptic attributes on Red Lady papaya fruit at different storage conditions and stages of maturity

Treatments	Sensory Attributes							
Storage Condition (A)	Juiciness[*]	Color[**]	Aroma [ns]	Sweetness [ns]	Taste [ns]	Off Flavor[**]	Off - Odor[**]	Over - all Acceptability [ns]
Ambient	9.40[a]	8.05[b]	8.88	9.18	8.69	0.45[a]	0.55[a]	9.09

Evaporative Cooler Refrigerator	8.98[b] 9.30[ab]	8.26[b] 8.72[a]	8.83 9.06	8.96 9.16	8.80 8.97	0.74[b] 0.33[a]	0.85[b] 0.41[a]	8.97 9.24
Stages of Maturity (B)	Juiciness[**]	Color[**]	Aroma[**]	Sweetness[**]	Taste[**]	Off Flavor[**]	Off - Odor[**]	Over - all Acceptability[**]
Start yellowing - 1/2 inch yellow	8.93[b]	8.30[ab]	8.79[b]	8.77[b]	8.65[b]	0.68[b]	0.68[b]	8.81[b]
1/2 - 1 inches yellow	9.27[ab]	8.21[b]	8.77[b]	9.14[ab]	8.68[b]	0.49[ab]	0.65[b]	9.16[a]
1 - 1.5 inches yellow	9.48[a]	8.53[a]	9.20[a]	9.39[a]	9.13[a]	0.36[a]	0.47[a]	9.34[b]

[1]Data based on the average of 6 fruits/treatments/replicate
[2]Ambient (ºC, RH, VPD), EC (ºC, RH, VPD), Refrigerator (ºC, RH, VPD)
[3]0.5 - inch yellow from the tip, 0.5 - 1 inch yellow from the tip, 1 - 1.5 inches yellow from the tip
[ns] Not Significant
[**] Highly Significant at 1% level
[*]Significant at 5% level

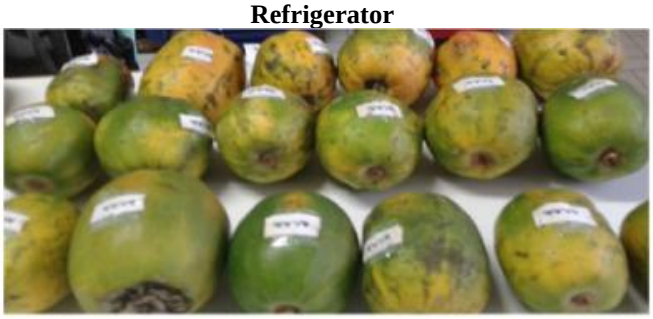
Table 3.1: Interaction effect on organoleptic attributes of Red Lady papaya fruitsat different storage conditions and stages of maturity

Treatments	Sensory Attributes							
	Juiciness [ns]	Color [**]	Aroma[**]	Sweetness [ns]	Taste[**]	Off - flavor [ns]	Off - odor [ns]	Over - all acceptability [ns]
Ambient								
Start yellowing - 1/2 inch yellow	9.01	8.2[bc]	8.5[c]	8.8	8.5[cd]	0.71	0.63	8.93
1/2 - 1 inches yellow	9.48	7.7[c]	8.6[c]	9.2	8.3[d]	0.31	0.56	9.11
1 - 1.5 inches yellow	9.76	8.2[bc]	9.4[bc]	9.5	9.3[ab]	0.22	0.47	9.25
Evaporative Cooler								
Start yellowing - 1/2 inch yellow	8.87	8.4[bc]	9.0[abc]	8.9	8.9[bc]	0.87	0.98	8.68
1/2 - 1 inches yellow	9.14	8.3[bc]	8.9[bc]	9.1	8.9[bc]	0.78	0.98	9.2
1 - 1.5 inches yellow	8.91	8.0[bc]	8.7[c]	8.9	8.5[cd]	0.58	0.6	9.01
Refrigerator								
Start yellowing - 1/2 inch yellow	8.94	8.3[bc]	8.8[bc]	8.6	8.4[cd]	0.33	0.44	8.81
1/2 - 1 inches yellow	9.2	8.5[b]	8.8[bc]	9.1	8.9[b]	0.38	0.42	9.17
1 - 1.5 inches yellow	9.76	9.4[a]	9.5[a]	9.7	9.6[a]	0.27	0.36	9.75
CV	2.07	13.49	14.94	10.87	14.02	16.68	11.17	2.02

[1]Data based on the average of 6 fruits/treatments/replicate
[2]Ambient (ºC, RH, VPD), EC (ºC, RH, VPD), Refrigerator (ºC, RH, VPD)
[3]0.5 inch yellow from the tip, 0.5 - 1 inch yellow from the tip, 1 - 1.5 inches yellow from the tip
[ns] Not Significant
[**] Highly Significant at 1% level
[*] Significant at 5% level

Ambient

Refrigerator



Evaporative Cooler

Figure 4: Visual Quality Rating on Red Lady papaya fruits assessed during storage period. VQR as an indicator of the salability of the fruits and shelf life. Fruits stored at ambient, EC and refrigerator to prolong postharvest life of fruits. EC stored fruits obtained a uniform yellow color than ambient and refrigerator

6. Summary, Conclusion and Recommendation

6.1 Summary

The study on the Sensory Evaluation on the Organoleptic attributes of Red Lady Papaya Fruits at Different Maturity Stages and Storage Conditions was conducted at the Postharvest Processing area of Surigao del Sur State University – Tagbina Campus, Tagbina, Surigao del Sur from June, 2016 to March, 2017. Its objectives were to: determine the postharvest characteristics of Red Lady papaya fruits harvested at different maturity stages or ripeness, evaluate the effectiveness on the ripening of papaya as influenced by storage conditions and evaluate the organoleptic attributes of papaya in terms of taste, aroma, pulp color, juiciness, sweetness and over - all acceptability of consumers.

Two factorial experiments in Completely Randomized Design (CRD) were used in the study. The first experiment determined the effect of stages of maturity and storage conditions, while the second experiment determined the effect of modified atmosphere packaging (MAP) and storage conditions.

Results showed that the temperature, relative humidity and VPD were lowest in refrigerator while RH was highest in EC. A humid and reduced VPD condition prevails in a MA chamber due to the presence of condensed moisture in addition to low oxygen and high CO_2 atmosphere. These conditions reduced or retarded the rate of peel yellowing, sensory firmness, organoleptic attributes andimprovedthe visual quality and prolonged the postharvest life of Red Lady papaya fruits. Red Lady papaya fruits can be stored longer in refrigerator than in ambient or EC conditions. and improved visual quality of the fruits. Stage of maturity in Red Lady papaya fruits had no significant difference in chilling injury but fruits did not attain full ripeness due to deterioration of the fruit that had occurred. Significant results occurs in color changes, aroma and taste of the fruits.

6.2 Conclusions

Based on the results of the study, the following conclusions were drawn:

1) Red Lady papaya fruits can be stored longer in refrigerator conditions than in ambient and EC conditions.
2) Refrigerator or cold storage can prolong the postharvest life of Red Lady papaya fruits stored than in ambient and evaporative cooler.
3) Organoleptic attributes of the fruits is significant in aroma, peel color and taste which greatly highly dependent on consumers preference of the fruits.

6.3 Recommendations

The author highly recommends that papaya fruits be stored in refrigerator to prolong or extend shelf life. Fruits be harvested at the right stage of maturity and observed proper handling of the fruits prior to storage.

Further study on the use of MAP with perforation and fruit treatment with organic sprays prior to storage to prolong the storage life of papaya fruits is also recommended.

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