POST-HARVEST TREATMENT OF PAPAYA
(CARICA PAPAYA L.)

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POST-HARVEST TREATMENT OF PAPAYA (*CARICA PAPAYA* L.)

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Post- Harvest treatment of papaya (Carica papaya L.)

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ABSTRACT
Post-harvest treatment of cv.Exotica and cv. One foot papaya was carried out. The fruits were subjected to three treatments ie: dipping in hot water bath at 48°C for 20 minutes and stored at 10°C, dipping in hot water bath at 60°C for 1 minute and stored at 10°C and stored at ambient without any treatment. The fruit colour was observed and recorded from day 0 until 21. It was found that cv. Exotica and cv. One foot papaya can be kept for up to 21 days when treated with hot water at 48°C for 20 minutes and at 60°C for 1 minute. For control, cv.Exotica papaya can be kept for not more than 7 days meanwhile cv. One foot papaya can last for not more than 6 days. Samples were analyzed for quality parameter such as acidity, total soluble solids, vitamin C, pH and Brix after every two days interval ie: day 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20. Statistical analysis showed that there were no changes quality parameters for both varieties during storage and due to different treatment temperature. However, there were changes in some quality parameters due to different treatment temperature and during storage. Analysis result showed that post-harvest treatment of papaya can last for up to 20 days or longer when treated at 48°C and 60°C for 20 minutes and 1 minute respectively. The ambient samples could only be kept for not more than 7 days for cv.Exotica papaya and not more than 6 days for cv. One foot papaya.

Keywords: post-harvest treatment, cv.Exotica and cv. One foot

ABSTRAK

# TABLE OF CONTENTS

AKNOWLEDGEMENT 

ABSTRACT/ ABSTRAK 

TABLE OF CONTENTS 

CHAPTER 1 INTRODUCTION 

1.1 Background 

1.2 Problem Statement 

1.3 Objective 

CHAPTER 2 LITERATURE REVIEW 

2.1 Botanical description of papaya 

2.2 General Description 

2.3 Origin 

2.4 Economic significance 

2.5 Post-harvest treatment 

2.6 Post-harvest storage 

2.7 Post-harvest physiology and disorders 

2.8 Pathology and control of disease 

2.9 Handling system 

CHAPTER 3 MATERIALS AND METHODS 

3.1 Materials 

3.2 Methods 

3.2.1 Control treatment
3.2.2 Effect of temperature on colour index and quality of papaya fruits

3.2.2.1 Harvesting, grading, washing, treatment and storage of fruits
3.2.2.2 Colour Index observation
3.2.2.3 Quality Assessment
3.2.2.4 Experimental design and statistical analysis
3.2.2.5: Disease Identification

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Changes of colour index during fruit ripening (Control)
4.2 Effect of temperature on colour index and quality of papaya

4.2.1 Colour index observation
4.2.1.1 Colour Index observation for cv. Exotica papaya
4.2.1.2: Colour Index observation for cv. One foot papaya
4.2.2 Data analysis
4.2.3 Disease Identification

CHAPTER 5 CONCLUSION AND RECOMMENDATION

REFERENCES

APPENDICES
Appendix 1 Nutrient composition of papaya.
Appendix 2 Acidity (Titratable) in fruits juice.
Appendix 3 Vitamin C in fruits and vegetable juice.
Appendix 4 Total soluble solids in fruits juice.
Appendix 5  Photos taken during experiment.

a) Methods of post-harvest handling and treatment or papaya fruit. 62

b) Fruit analysis at chemistry laboratory. 63
CHAPTER 1
INTRODUCTION

1.1 Background

The common papaya, *Carica Papaya* L., is a native of American Tropical lowlands. The papaya fruit is an important fruit, both as fresh fruit and processed products. Papaya belongs to the family Caricaceae. The other names of papaya are Pawpaw, Mikana, Milikana, Papaia, and papain.

The fruits are smooth-skinned. They vary widely in size and shape, depending on the variety and the type of plant. The fruits usually contain many seeds surrounded by transparent arils. The edible part is the mesocarp which is sweet and smooth yellow to orange-red.

Post-harvest handling and treatment are important that allowed quality to be retained over an increasingly longer period. Extending the post-harvest life of produce requires knowledge of all the factors that can lead to loss of quality or the generation of unsaleable material. The knowledge is also useful in developing affordable technologies that minimize the rate of deterioration (Wills *et al.*, 1998).

The fruit section of the Agriculture Research Centre (ARC) at Semongok, Sarawak planted two recommended cultivars of papaya, ‘Exotica’ and ‘One foot.’ cv. Exotica, is the most popular cultivar, in Malaysia. ‘One foot’ is also called ‘sekaki’ in Malaysian
local language. The introduction of new variety, Exotica from MARDI in 1987 to ARC are due to its superior variety quality. Improve post-harvest technology which allowed papaya to be transported to distant markets enabled papaya to become an export commodity. cv. ‘Exotica’ developed by MARDI, is the result of a cross between Sunrise Solo and Subang 6. Its starts to fruit at 4 months after planting. The fruit weight about 600-800g with high sugar content (Brix 13-15%). The flesh is red orange in colour.

cv. Exotica II has a good commercial potential because of the stability in quality and precocious high yielding characteristic. Papaya cultivar ‘One foot’ is also a popular fruit. Its flesh is red-orange in colour and approximately one-foot length.

The papaya is a very wholesome fruit providing cheap sources of vitamins and nutrient in the daily diet of the people (Appendix I). Ripe papaya is usually consumed fresh as a breakfast or desert fruit. Papaya fruit can be processed into a variety of products such as jam, jelly, nectars, ice-cream, sherbet or cooked as substitute for apple source.

Papain is the milky latex of the unripe papaya fruit, leaves and other part of the plant. Papain is a proteolytic enzyme that digests proteins. The enzyme is used as a meat tenderizer and for medical and industrial purposes (Mitra, 1997).
1.2 Problem Statement

Many of the fruits have short storage-life. This is due to high losses and disease infections. As an example, papaya fruit which was exposed to ambient temperature without any treatment only can be stored for about 3 days (Lau, 2005). It is desired to develop a good post-harvest treatment to extend the shelf-life and maintain the quality of papaya fruits.

1.3 Objective

The aim of the study is to determine appropriate treatments for maintaining fruit quality and extending the shelf-life of papaya fruits.
CHAPTER 2
LITERATURE REVIEW

2.1 Botanical description of papaya

Papaya (Carica Papaya L.) belongs to Caricaceae, a small family that includes only four genera: Carica, Cylocomorpha, Jacaratia, and Jarilla. Except for the genus Cylocomorpha, which originates in equatorial Africa, the other members of the family are native to the American Tropics. The genus Carica is the most important and widely cultivated among the 21 species in the genus (Ploetz et al., 1994).

2.2 General Description

Papaya is a large herbaceous plant with a single erect stem and a crown of large, palmately lobed leaves. The main stem is hollow and the bark is smooth and has prominent leaf scars. Petiole of mature leaves usually extend horizontally from the main stem and are approximately 45-70 cm in length, depending upon the cultivar. Flowers are borne in modified cymes inflorescences that appear in the axil of the leaves. The type of inflorescence that is produced depends upon the sex of tree. Papaya fruit superficially resemble melons. Fruit from female trees are spherical, whereas those from hermaphroditic trees are pyriform, oval, or elongate. The fruit is composed of five carpels that unite to form a cavity. Fruit size ranges from 225g to 6 kg. Fruit flesh color ranges from pale to bright and orange yellow to red. Fruit total soluble solids range from 5-18%.
These characteristics differ according to cultivar and environmental conditions (Ploetz et al., 1994)

2.3 Origin

The papaya is believed to be a native of tropical America (Rohani, 1994). The exact place of origin is not known, but Spanish and Portuguese sailors were responsible for the dissemination of the papaya to the tropical and subtropical countries (Chan et al., 1994). Today, it is widely grown in tropical and subtropical countries especially those that are situated between latitude 32°N and 32°S. Carica papaya may have arisen by hybridization (Rohani, 1994).

2.4 Economic significance

Only the common papaya, Carica papaya L. has high economic value. Besides providing food to the people, this crop has the potential to be exploited as an income generator. This can be accomplished by exporting and strategic marketing, especially in countries where papaya fruits are in demand (Rohani, 1994). In 1984, Malaysia alone exported about 15,000 tonnes of papaya worth RM 3.4 m (US$1.36m) (Rohani, 1994). There was a two-fold increase in papaya exports in 1991 when Malaysia exported about 22,773 tonnes worth about RM 23.8 m (US$9.52 m) (Rohani, 1994).

2.5 Post-harvest treatment

Post-harvest treatment is applied to fruit either to maintain quality or to improve visual appeal. Wastage of fruits by microorganism between harvest and consumption can be
rapid and severe particularly in tropical areas where high temperature and high humidity favour rapid microbial growth. Post-harvest wastage of fruits maybe reduced by low and high temperatures, modified atmospheres, correct humidity, irradiations and good sanitation.

Heat treatment in the form of either moist hot air or hot water dips have some commercial applications for the control of post-harvest wastage in papaya, mango, stone fruits and cantaloupe (Wills et al., 1998). The advantage of hot water dipping is that it can control surface infections as well as infections that have penetrated the pericarp (skin), and it leaves no chemical residue on the fruits.

Hot water dipping must be precisely administrated as the range of temperature necessary to control wastage approaches temperature that damage the fruits. According to Morton (1987), a 20 minutes immersion in water at 49°C followed by a cool rinse could control decay of fruit. The same author also reported (Morton, 1987) that in Hawaii, papaya fruit picked at ¼ ripe prewarmed in 43.3°C for about 40 minutes followed by immersing in 48.3°C for 20 minutes was the post-harvest treatment for papaya before irradiation was used to sterile the fruits.

In Trinidad and Tobago it was reported that a hot water treatment of 48-50°C for 20 minutes was found to be effective in delaying the rotting of fruits during storage. Such hot water treatment did not affect the sensory quality of the fruit (Allong et al., 2000).
Mango (Mangifera indica L.) is a climacteric fruit. Under ambient temperatures the shelf-life of this fruit is short, about 7-14 days to become ripe. It was found (Nakasone et al., 1998) that pre-cooling to 10-13°C was beneficial during hot weather or when shipping was delayed.

2.6 Post-harvest storage

Proper storage practices are required for papaya fruit to avoid quality deterioration, primarily due to decay and accelerated softening. Storage is seldom done for fruit which are destined for local markets. However, fruit exports require an optimum storage environment. Papaya fruit can be stored at ambient temperature (28-32°C) for about a week. Under refrigeration and when the temperature was decreased to 15°C, papaya fruit cv. Exotica remained at colour index 1 for 22 days. However, papaya is a tropical fruit and should be stored at an optimum temperature of about 10-13°C to prevent chilling injury (Rohani, 1994). Papaya fruits of cv. Exotica could be kept at 10°C for two to three weeks and then ripe at 25°C (Lam and Sepiah, 1989). The storage life of papaya fruit can be extended by hot water treatment which is effective in retarding disease infection (Rohani, 1994).

2.7 Post-harvest physiology and disorders

In papaya, two physiological disorders have been studied, chilling and hyperthermal injuries. Physiological disorders in harvested fruits defined as disturbances in the normal functioning of the fruit tissues is due to adverse environmental conditions during
handling, improper post-harvest handling and storage treatments or nutrition deficiency during growth and development (Rohani, 1994).

Chilling injury in papaya is induced by exposing fruit to low but nonfreezing temperatures (Broughton et al., 1977; Chan et al., 1985; Chen and Paul, 1986; An and Paull, 1990). Hyperthermal injury occurs in papaya when exposed to heat. This is due to vapour heat treatment, hot water treatment or ambient temperature (Rohani, 1994).

For mango, the disease usually appears during the initial stages of maturity, with loss of firmness of the pulp near the endocarp which becomes jelly-like translucent with advancing ripeness. The disorder does not develop after harvest. The only recourse for the fruit at the mature green stage, before any colour break occurs on the skin (Nakasone et al., 1998).

2.8 Pathology and control of disease

Many bacteria and fungi such as Colletotrichum, Phomopsis, Phytophthora, Rhizopus, and Fusarium are responsible for enormous losses after harvest. It is important to determine the pattern of infection of the various organisms so that appropriate control measures may be developed to eliminate the disease (Rohani, 1994; Ploetz et al., 1994).

The following fungi had been isolated (Echerenwa and Umecheruba, 2004) from papaya in Nigeria: Fusarium solani, Phoma carica papaya, Aspergillus flavos, Aspergillus niger, Botryodiplodia theobromae, Cladosporium herbarum, Colletotrichum dematium,
Fusarium moniliforme, Phomopsis carica-papaya, Penicillium sp, and Rhizopus stolonifer.

Nakasone et al. (1998) reported the appearance of six species of *Fusarium* on mango fruit. Bacterial Black spot (*Xanthomonas campestris*) of mango appears to be a relatively serious disease in South Africa and Australia. It also was seen in Hainan, China. Powdery mildew (*Oidium mangifera*) is a common disease of the dry subtropics.

2.9 Handling system

Papaya should be harvested at proper stage of maturity so that the fruits ripen normal and develop good flavour and taste. A systematic method of describing colour indices for papaya has been described by Lam (1989). The main concern in handling the papaya are harvesting practices, packaging, grading, standardization and transportation (Rohani, 1994). Post-harvest handling of papaya, especially Exotica for local and export markets required different handling system, depending on mode of transport. For long distance transport by ship, disease control and cold room storage are essential (Lam and Sepiah, 1987).
3.1 Materials

Papaya fruits from two cultivars, 'One foot' and 'Exotica' were used in this study. The papaya plants were grown in Agriculture Research Centre, Semongok on a Red Yellow Podzolic soil.

3.2 Methods

3.2.1 Control treatment

Papaya fruits with colour index 2 were harvested then washed with tap water and cleaned using soft sponge. Fruits were stored at ambient temperature (control). The changes in indices were recorded from day 0 until the fruit deteriorated and damaged. There were 25 samples of cv. Exotica and five samples of cv. One foot papaya. The lesions on the pericarps were examined and identification of the causal organism attempted. The quality test of cv. Exotica papaya with different indexes was done. These results were used as a
guideline to experiment carried out for colour index observation, fruit quality observation and time of appearance of lesion of the anthracnose disease.

3.2.2 Effect of temperature on colour index and quality of papaya fruits

3.2.2.1 Harvesting, grading, washing, treatment and storage of fruits

The fruit was harvested at colour index 2. The colour indices of papaya fruit is as follow:

<table>
<thead>
<tr>
<th>Colour index</th>
<th>Pericarp (skin) colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Full green</td>
</tr>
<tr>
<td>2</td>
<td>Green with trace of yellow</td>
</tr>
<tr>
<td>3</td>
<td>More green than yellow</td>
</tr>
<tr>
<td>4</td>
<td>More yellow than green</td>
</tr>
<tr>
<td>5</td>
<td>Yellow with trace of green</td>
</tr>
<tr>
<td>6</td>
<td>Full yellow</td>
</tr>
</tbody>
</table>

Plate 3. Colour indices of papaya fruits
Source: (Lam, 1987)

Harvested fruit was washed in tap water and cleaned using soft sponge. Then, the fruit was sorted out according to the colour index. For this study colour index 2 (pericarp is
green with trace of yellow) was preferred. Fruit was treated with hot water. The fruit was subjected to the three treatments:

T1 - Dipped in hot water bath at 48°C for 20 minutes and then stored at 10°C

T2 - Dipped in hot water bath at 60°C for 1 minute and then stored at 10°C

T3 - Stored at ambient temperature without dipped in hot water.

3.2.2.2 Colour Index observation

Fifty-four fruits were used for colour index observations (9 replicates/treatment/papaya species) after stored. The changes in indices were recorded from day 0 until day 21.

3.2.2.3 Quality Assessment

Three samples per treatment were taken out for analysis started from day 2 until day 20, with 2 days interval after storage. There were 117 samples used for quality parameter observations (3 replicates/treatment/papaya species) for 10 times analysis.

The analysis was done at chemistry laboratory of Agriculture Research Centre. The observed quality parameters recorded were including:

1) Acidity,

2) Total soluble solid (TSS)

3) vitamin C content

4) pH and

5) Brix reading
Methods of determination of acidity, vitamin C content and total soluble solid were attached as appendices (3-4). To determine pH of the juices, pH meter was used. For brix reading, hand refractometer was used.

3.2.2.4 Experimental design and Statistical analysis

The experimental design was a Split Plot Design with 3 main plots (pre-storage treatment), 3 subplots (storage period), 3 replicates/ treatment. The data were analyzed as two way analysis of variance.

3.2.2.5: Disease Identification

The incidence of diseases was checked. Fruit with the appearance of any disease was examined, identified and confirmed at the pathology laboratory of ARC. Infection on fruit was checked by first isolating and culturing of the organism. The main purpose of this process was to identify and confirm the fungus that causes the infection. The procedure was as follow:

a. Diseased plant tissue was cut into small pieces including some healthy tissue adjacent to the diseased part. This is usually consisting of tissue at the edge of a lesion.

b. The tissue was sterilized in 0.5% Sodium hypochlorite solution for 3 to 5 minutes in a beaker. The ratio of tissue to Sodium hypochlorite solution is 1:9.

c. The tissues were washed three times with sterilized distilled water.

d. The excessive water on the tissues was drained off by placing them at sterilized filter paper.
e. The tissue piece was transferred onto an agar medium (plain agar) in a petri dish before being transferred to a PDA (Potato Dextrose Agar) agar plate.

f. After 3-4 days, the fungal mycelia developed in the agar medium. A small piece of agar containing the mycelia was cut and transferred to a new agar plate of PDA. This step was also called subculture process.

g. The fungus grown on the agar was observed until spores or other fungal structures were formed. The morphology of the fungus was used for identification.

Photographs of treated samples were made so as to assist in the identification.
Chapter 4

Results and Discussion

4.1 Changes of colour index during fruit ripening (Control)

Observation on change of colour index of ‘Exotica’ fruits stored from day 1 until day 6 (Table 1) were made. On day 1, many of the samples were colour index 2, followed by colour index 3. On day 2, the number of samples with colour index 2 decreased. The number of fruit with colour index 3 increased and few samples which had changed into colour index 4. On day 3, most samples were with colour index 2 and 3. Quite a large number of sample were colour index 4. Few had changed into colour index 5 on day 3. On day 4, no observation were made because of the public holiday. On day 5, number of sample in colour index 2, and 3 decreased. Colour index 4 and 5 increased. On day 6, there were no sample with colour index 1. Many of fruit samples changed into colour index 5 and 6. This showed that, the colour of ‘Exotica’ fruit were changed into fully yellow and riped on day 6. (Table 1).

Table 1. Number of ‘Exotica’ fruits at specific colour index after different storage period

<table>
<thead>
<tr>
<th>colour index</th>
<th>day 1</th>
<th>day 2</th>
<th>day 3</th>
<th>day 4</th>
<th>day 5</th>
<th>day 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>15</td>
<td>9</td>
<td>NA</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>NA</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>NA</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>NA</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Total of Samples</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>NA</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

Note:
NA- Not available
No observation was made on that day as it was a public holiday, the author did not have the access to the facility.

Observation on changes of colour index during ripening of ‘One-foot’ was carried out with 5 samples (Table 2). On day 1, more samples were with colour index 2 than with colour index 3. On day 2, some sample had changed from colour index 2 to colour index 3. There was one sample changed into colour index 4. On day 3, the number of sample with colour index 4 were increased to two samples. On day 4, there were no observation been done because of the public holiday. On day 5, there were no sample with colour index 2. The samples were with colour index 3, 4 and 5. On day 6, there were no sample with colour index 2 and 3 and mostly of the sample can be found with colour index 4, 5 and 6. On day 6, two samples with colour index 6 showed that ‘One-foot’ papaya fruit were fully yellow and riped (Table 2).

Table 2. Number of ‘One-foot’ fruits at specific colour index after different storage period

<table>
<thead>
<tr>
<th>colour index</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>NA</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>NA</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>NA</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total of samples</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Note:
NA- Not available

No observation was made on that day as it was a public holiday, the author did not have the access to the facility.
The lesion on pericarp of fruits was examined on day 5 and day 6 (Table 3). For assessment of severity, those having less than five lesions were moderate and more than 5 lesions were severe. Lesion were considered moderate for ‘Exotica’ papaya fruit at colour index 2 and 3 and severe when reach colour index 4 and 5 on day 5. Compared to day 5, lesion on day 6 were more severe. For ‘One-foot’ fruit, lesion on pericarp (skin) were assumed severe for fruit started with colour index 3. (Table 3).

Table 3. Number of lesion after four to five days in two cultivars of papaya.

<table>
<thead>
<tr>
<th>Color Index</th>
<th>'Exotica' papaya</th>
<th>'One foot' papaya</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 5</td>
<td>Day 6</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>&lt;5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>3</td>
<td>&lt;5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>4</td>
<td>&gt;5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>5</td>
<td>&gt;5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>6</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Note:

<5 spots = moderate
>5 spots = severe
NA- Not available as fruits has spoiled

To measure the quality of papaya, there were five parameters were used. These were acidity, brix reading, pH, total soluble solid (TSS) and vitamin C. Table 4 shows the quality analysis at different colour indices of ‘Exotica” papaya fruit. The acidity percentages ranged between 0.14 and 0.15. The higher percentage of brix reading (sweetness) were for fruit samples with colour index 5. The pH showed the fruit samples were classified as acid group. Total soluble solid increased with the colour index. Lastly, the vitamin C was also increased with colour index (until index 4). Table 4 showed that the vitamin C decreased once the ‘Exotica’ fruits sample turned into colour index 5.