EFFECT OF DIFFERENT HARVESTING DATES ON SHELF-LIFE OF CHILI, *Capsicum annum* var. Kulai

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EFFECT OF DIFFERENT HARVESTING DATES ON SHELF-LIFE OF CHILI, *Capsicum annum* var. Kulai

By
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Research Report submitted in partial fulfilment of the requirements for the degree of Bachelor of Science in Agrotechnology (Post Harvest Technology)

DEPARTMENT OF AGROTECHNOLOGY
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ENDORSEMENT

This project report entitled **Effect of Different Harvesting Dates on Shelf-life of Chili, *Capsicum annum* var. Kulai** by **Noor Ain Binti Mohd Faudzi**, Matric No. **Uk14700** has been reviewed and corrections have been made according to the recommendations by examiners. This report is submitted to the Department of Agrotechnology in partial fulfilment of the requirement of the degree of Bachelor of Science in Agrotechnology (Post Harvest Technology), Faculty of Agrotechnology and Food Science, Universiti Malaysia Terengganu.

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DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

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ABSTRACT

Yield quality at the consumer level depends not only on the storage, handling and packaging conditions after harvest, but also on the environmental factors and maturity or harvesting dates. Determination of optimum harvesting date is very important to improve the shelf life of fruits during the storage because the quality of fruits can be different by with different harvesting dates. This study was conducted to determine the effect of three different harvesting dates [first harvesting; 53 day after flowering, second harvesting; 60 day after flowering, third harvesting; 63 day after flowering] on chili, (*Capsicum annum* var. kulai), on the shelf-life during storage at ambient temperature. Physical characteristics were determined by quantitative measurements of color changes, weight loss and texture (firmness), also chemical evaluation of pH. Generally, the quality of chili deteriorated with increase in storage time. Among all the harvesting dates, it was found, that the normal practices by the farmer of harvesting chilli on day 60 after flowering (second harvesting), could extend the shelf life of chili with minimum change in color (a*value), weight loss, and texture (firmness). However, there was no significant change in other parameters tested. The third harvesting for chili was found to be least effective is maintain the quality of the crops followed the first harvesting.

ABSTRAK

Permintaan pengguna terhadap kualiti hasil sayuran,bukan saja bergantung kepada proses penyimpanan, pengakutan dan pembungkusan selepas di tuai, tetapi faktor persekitaran, kematangan dan juga waktu penuaian perlu di ambil kira untuk memastikan kualiti sayuran tersebut. Penentuan waktu penuaian yang terbaik adalah paling penting bagi memanjangkan jangka hayat sesuatu sayuran semasa proses penyimpanan, ini kerana kualiti sayuran boleh dipengaruhi oleh waktu penuaian. Kajian ini dijalankan untuk menentukan sama ada waktu penuaian yang berbeza (tuaian pertama:53 hari selepas berbunga, tuaian kedua: 60 hari selepas berbunga, tuaian ketiga:67 hari selepas berbunga) mempengaruhi jangka hayat cili (*Capsicum annum* var. kulai) semasa proses penyimpanan pada suhu ambien. Ciri-ciri fizikal ditentukan melalui ukuran kuantitatif perubahan warna, kehilangan berat dan keteguhan tekstur isi, serta penilaian kimia pula melibatkan pH. Secara umumnya, kualiti cili menggalami peningkatan kemerosotan seiring dengan pemanjangan tempoh penyimpanan. Diantara ketiga-tiga waktu penuaian, adalah dikanalpasti bahawa waktu penuaian yang sering digunakan oleh petani iaitu 60 hari selepas berbunga (waktu penuaian yang kedua), dapat memenjangkan jangka hayat cili dengan sedikit sahaja perubahan warna, kehilangan berat dan keteguhan tekstur isi cili. Walau bagaimanapun ia tiada perbezaan yang ketara didalam parameter – parameter lain yang uji. Waktu penuian cili yang ketiga (67 hari selepas berbunga) telah dikenalpasti kurang efektif dalam mengekalkan kualiti sayuran, diikuti oleh waktu tuai yang pertama (53 hari selepas berbunga).

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LIST OF ABBREVIATIONS

e.g	: example
mg	: milligram
g	: gram
%	: percentage
°C	: Degree of Celsius
16”	: 16 inch
ml	:milliLiter

CHAPTER 1

INTRODUCTION

1.1 Background of study

Yield quality at the consumer level depends not only on the storage, handling and packaging conditions after harvest, but also on the environmental factors and maturity or harvesting date (Mathieu, L and Jacques, J. 2007). The factors can be controlled by various cultural practices, i.e. light and temperature through tree pruning, carbon availability through fruit thinning, or water availability through irrigation management.

Determination of optimum harvesting date is very important to improve the shelf life of fruits during the storage because the quality of fruits is influenced from the one of pre-harvest such as harvesting date. According to Ali (2008) determination of optimum growing techniques, e.g. sowing and harvesting dates, is very important for yield and quality.

Generally the different harvesting date of fruit also affects the value or the quality of the fruits, cause if the harvesting date is early, the contents of sugar or vitamin C in fruit is low, and also the fruits will be immature during the harvest and if the harvesting date is late, maybe the sugar or vitamin C in fruits is high, but the fruits will be over mature and the shelf-life of fruits is short. The harvesting date on short term plant also refers to the period of the planting. For example, in chili (*Capsicum annum* var Kulai) will be harvested at fourth or fifth months after planting (Ashraf M,

2008) using fertigation system. But it is not the best harvesting date, because the farmer will harvest when the chili is ready red and the shelf-life of chili isn't to long.

1.2 Problems Statement

Nowadays the harvesting dates for fruits or vegetable depend on the maturity, color of fruits or demand from market. The harvesting date will be influenced by the quality of fruits during the storage. If the harvesting date is early, the shelf-life of fruits or vegetable is longer, but the fruits will be immature and also the amount of nutrition content is low. If the harvesting date is late, may be the shelf-life of fruits is short and the fruits will be over mature. So, this study was conducted to determine the best harvesting dates of chili to improves the shelf-life during storage and to make sure the nutrition in fruits is high.

1.3 Significance of study

This study is designed to investigate the best harvesting date on chili variety Kulai Chili 568 F1 Hybrid by using the fertigation system. This study can help farmers to settle this problem about harvesting date on chili (*Capsicum annum* var Kulai). This study can also show the effect of different harvesting date on the shelf-life of chili (*Capsicum annum* var Kulai) during storage at ambient temperature as it might depend on the harvesting dates.

1.4 Objective

The main objectives of this project are:

1) To investigate the optimum harvesting dates of Chili, *Capsicum annum* var Kulai growth under by fertigation system.

2) To determine the effect of harvesting date on the shelf-life of chili, *Capsicum annum* var Kulai.

CHAPTER 2

LITERATURE REVIEW

2.1 Chili

Chili pepper (also known as, or spelled, chilli pepper, chilli, chillie, chili, and chile) is the fruit of the plants from the genus *Capsicum*, members of the nightshade family, Solanaceae. Botanically speaking, the fruit of capsicums are berries. They are very pungent, containing capsaicin (C18H27NO3) in their placenta (Purseglove 1968).

Depending on flavor intensity and fleshiness, their culinary use varies from use as a vegetable (e.g. bell pepper) to the use as a spice (e.g. cayenne pepper). It is the fruit that is harvested. .Chili peppers originated in the Americas and their cultivars are now grown around the world, because they are widely used as food and as medicine.

In this study, the chili using is *Capsicum annuum* (Purseglove et al. 1981). Capsicum fruits contain coloring pigments, pungent principles, resin, protein, cellulose, pentosans, mineral elements and very little volatile oil, while seeds contain fixed (non-volatile) oil. The fruits of most Capsicum species contain significant amounts of vitamins B, C, E and provitamin A (carotene) when in a fresh state.

The large type of C.annuum is among the richest knowing sources of vitamin C, which may be present up to 340 mg/100g in some varieties (Purseglove et al. 1981). Postharvest quality of fresh pepper (*Capsicum annuum* var kulai) fruit is influenced by physiological and pathological factors. The principal physiological factors that negatively impact pepper fruit during shipment and storage and subsequent marketing are water loss (Lownds et al., 1993; Maalekuu et al., 2002; Watada et al., 1987) and chilling injury (Hardenburg et al., 1986: Paull, 1990).

2.2 Harvesting

In agriculture, the harvest is the processes of gathering mature crops from the fields. Harvesting in general includes an immediate post-harvest handling, all of the actions taken immediately after removing the crop-cooling, sorting, cleaning, packing-up to the point of further on-farm processing, or shipping to the wholesale or consumer market.

For the chili, harvesting based on color and size and depends on variety and market requirements, some are harvested when they change from green to red. Capsaicin content was highest in fruit harvested at the initial coloring stage, followed by those in fruits of reddening and greening stages (Park et al. 2001).

For Capsicum annum, crop starts yielding green chilies 40-50 days after transplanting. Dry chilies can be harvested 70-80 days after transplanting. Fruits are hand picked (Nybe E. V. et al. 2007).

2.3 Shelf-life

Shelf life is the recommendation of time that products can be stored, during which the defined quality of a specified proportion of the goods remains acceptable under expected (or specified) conditions of distribution, storage and display (Gyesley, S. 1991).

The combination of factors such as water activity (a_w), pH, redox potential, temperature, and incorporation of additives in preserving fruits and vegetables is important, and all play a crucial role in improving the shelf life of fresh and processed commodities (Gustavo V. 2003).

The sugar content was higher in fruits of initial coloring and reddening stags than those of the greening stage. The ascorbic acid content was highest in the reddening fruits followed by the initial coloring fruits and green fruits, while storage losses of ascorbic acid were higher in fruits of the greening stages (Park et al. 2001).

During storage, the highest rates of ethylene production and respiration rate were in fruits harvested at the initial coloring stage followed by those fruits at the greening and reddening stages (Park et al. 2001). The shelf life at simulated room temperature of 24±0.20C and 60% R.H was show to be only 2 – 3 days (Mercantilia, 1989).

Table 2.1: Storage recommendations (Anon, 1968; Lutz and Hardenburg, 1968; Mercantilia, 1989; Snowdon, 1991)

Temperature (^{0}C)	Relative humidity (%)	Storage
0 – 10	60 -70	6 -9 months
10	90	2 – 3 weeks
7 – 10	90 -95	1 -3 weeks
10	90 - 95	14 -21 days

2.4 Fertigation

Fertigation is the process of applying mineral fertilizers to crops along with the irrigation water. Fertigation in various trickle-irrigation technologies involves the injection of fertilizer solutions into irrigation systems via calibrated injection pumps. The daily application rate of fertigation changes during the growing season and is planned to meet the plant's daily demands according to its nutrient-uptake strategy (Ashraf M, 2008).

Fertigation has some specific advantages over broadcast and band fertilization, a frequent supply of nutrients reduces fluctuation of nutrient concentration in soil, there is efficient utilization and precise application of nutrients according to the nutritional requirements of the crop, fertilizers are applied throughout the irrigated soil volume, nutrients can be applied to the soil when soil or crop conditions would otherwise prohibit entry into the field with conventional equipment (Ashraf M, 2008). The fertilizer industry has adapted to field demands by introducing pure and soluble fertilizers.

The time-consuming process of the dissolution of various fertilizers has led to the development of liquid fertilizer blends, according to specific recipes as ordered by growers to meet the demands of specific plants at particular growing stages and under certain climatic conditions. The use of conventional, broadcast application of fertilizers becomes ineffective with a drip-irrigation system (Ashraf M, 2008). .An adequate supply to satisfy plant demands for nutrients from a limited soil root volume can only be achieved by synchronizing the supply of water and nutrients during the various growing stages of the plants. The units used to plan fertigation are: milligrams of a nutrient consumed per day per plant, rather than kilograms of a nutrient per hectare (Ashraf M, 2008).

2.5 Pests and Diseases

Thrips, aphids and mites are main pests. Damping off, anthracnose, leaf curl, mosaic and powdery mildew are major diseases. Continous cultivation of the crop in an area also leads to serious icidense of bacterial wilt (Gopalakrishnan et al, 1998). But in planting by fertigation not many pest or diseases attack, causes fertigation not using soil, so it is free from pet and diseases causes by soil. Just insect, worm and fungus attack plant (Ashraf M; 2008).

2.6 Pesticide and Fungicide

A pesticide is a substance or mixture of substances used to kill a pest. A pesticide is any substance or mixture of substance intended for preventing, destroying, repelling or mitigating any pest. A systemic pesticide moves inside a plant following absorption by the plant.

With insecticides and most fungicides, this movement is usually upward (through the xylem) and outward. Increased efficiency may be a result. Systemic insecticides which poison pollen and nectar in the flowers may kill needed pollinators such as bees. Pesticides can save farmers' money by preventing crop losses to insects and other pests; in the US, farmers get an estimated fourfold return on money they spend on pesticides (Kellogg, RL. 2000).

One study found that not using pesticides reduced crop yields by about 10% (Kuniuki, S. 2001). Another study, conducted in 1999, found that a ban on pesticides in the United States may result in a rise of food prices, loss of jobs, and an increase in world hunger.

CHAPTER 3

METHODOLOGY

3.1 Material

Seeds variety Kulai Chili 568 F1 Hybrid was supplied by Abiagro Sdn.Bhd, fertigation system, fertilizer A and B, glassware, pH meter (model WTW Ph 702, Wissenchaftich – Tenische Werkstatten), refractometer, texture analyzer (Stable Micro System TA.XT plus texture analyzer) and chormameter (Chromameter model CR-200, Minolta).

3.2 Methods

Sample of chili (*Capsicum annum* var. Kulai) ware cultivation on fertigation system at Green House Universiti Malaysia Terengganu (UMT) and the analyzed was conducted in the Postharvest technology Laboratory at Department of Agrotechnology, Universiti Malaysia Terengganu (UMT).

3.2.1 Seed Germination

Seeds variety Kulai Chili 568 F1 Hybrid was used on this study. Seeds were soaked for 24 hours before seedling in the tray with peat moss medium. In this study, the peat moss medium was used because it contains fertilizer, nutrients and suitable for seedling growth. The seedlings were watered twice daily. After 25-30 days, the seedlings were transferred to the polybag supplied (16"x 16") with fertigation system.

3.2.2 Plant growth under Fertigation

In fertigation, mineral fertilizers it applied to the crops along with the irrigation water and without using the soil. In this study, the compost medium of wood dusts was used. The fertigation system in various trickle-irrigation technologies involves the injection of fertilizer solutions into irrigation systems via calibrated injection pumps.

Therefore, plant was able to get enough nutrients from the irrigation during growth. In fertigation, the watering was set to release water five times daily and the quantity of water with fertilizer and time for irrigation depend on the size of plant. In these study two types of fertilizer used fertilizer A and B.

A little solution of fertilizer A and fertilizer B was added the water and by using an EC Meter (Electron Conductivity Meter) to ensure that enough quantity of fertilizer was applied. Table 3.1 showed the rate of fertilizer needed in this fertigation system.

Table 3.1: Fertilizers requirement during irrigation.

Weeks	Time (6 time/day)	Minute	EC Meter
1	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	4	1.4 -1.6
2	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	5	1.4 -1.6
3	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	5	1.6 -1.8
4	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	5	2.0 -2.2
5	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	5	2.2 -2.4
6	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	5	2.4 -2.6
7	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	5	2.4 -2.6
8 until end	7.30am, 9.30am, 11.30am, 1.30pm, 3.30pm, 5.30pm	6	2.5 -2.6

Source: Ashraf M; 2008

During plant growth, every plant in the polybag was supported by a stick to avoid plant fall. At weekly, all plant was spray with pesticide or fungicide to avoid any diseases and pest. In this study, the data were the tacked at three harvesting dates. For every harvesting date, three plants will be recorded (18 plants). Figure 3.1 are showed the days for plant growth in chili (*Capsicum annum* var. Kulai) (Ashraf M; 2008).

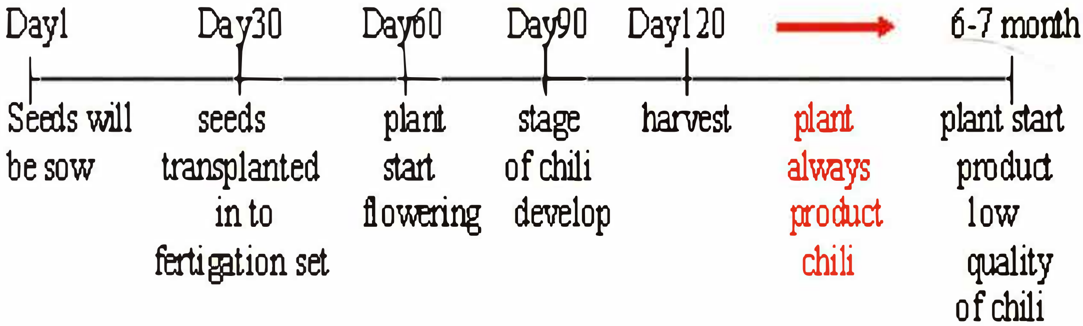

Figure 3.1: Flow diagram of the plant growth from 1st day until the end of plant for kulai chili (Ashraf M. 2008).

3.2.3 Tagging

First tagging was done when the plant started to display the full flowering, at first day of corolla opening (Figure 3.2). Then the further flower and fruit development are monitored frequently until harvesting date. The chili was harvested manually.

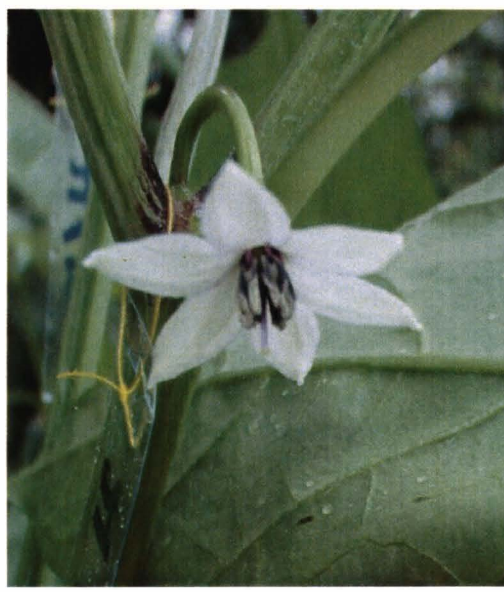

Figure 3.2: Flower open (tag as a first day).

3.2.4 Harvesting dates

In this study, the harvesting of fruits was done three times for the chili (*Capsicum annum* var. Kulai). First harvest was one week earlier than actual harvesting date normally practiced by farmer. The second harvesting date is the date as practiced by the farmer (control).

The third harvest is one week after the second harvest. Usually farmer harvest the kulai chili at day 60 after flowering. So the first harvest was on day 53 and third harvest on day 67 (Appendix G).

3.2.5 Fruits Analysis

The harvested, chili (*Capsicum annum* var. Kulai) was analyzed on the day of harvesting and every three days after harvesting throughout the storage at ambient temperature for two weeks. The following physical and chemical analyses were made on the stored chilis sample at room temperature:

I. % Weight Loss

II. Firmness

III. Color Changes

- L value
- a* Value
- b* Value

IV. pH

3.3 Physical analyses

3.3.1 Weight loss evaluation

The weight loss of fruits was determined by water loss in fruits during the analysis. Postharvest water loss of vegetables results in fruit softening, and reduced glossiness and shelf life (Kerstiens, 1996). The weight loss of chili was recorded before and after storage. Usually, the weight was recorded by electronic balance. Weight loss was reported in percentage (%). % weight loss was determined by following the calculation:

%Weight loss = [(initial weight - final weight)/ initial weight] x 100

3.3.2 Texture profile analyses

Texture analysis was done on sample to determine the level of firmness by using the Stable Micro System TA.XT plus texture analyzer. The probe used on this study was P2N Needle. The firmness of sample depends on the maturity; immature fruits are firmer compared to the over matured or matured fruits. So the texture analysis for chili will be tested at three different parts on each chili (Capsicum annum var. Kulai) during analysis.

3.3.3 Color evaluation

The skin color was determined for chili by using colorimeter (Chromameter model CR-200, Minolta) and expressed as numerical values of L* indicates lightness, a* indicates chromaticity on a green (-) to red (+) axis, and b* chromaticity on blue (-) to yellow (+) axis based on chromaticity diagram and mean value calculated. Three readings was taken on each fruits (upper site, middle site and lower site).

3.4 Chemical analysis

3.4.1 pH evaluation

pH of chili was determined to know the value of acidity in chili. Sample was blended and the juice from blender was used to determine the pH. By using pH mater (model WTW Ph 702, Wissenchaftich – tenische Werkstatten), value of the pH for the sample was determined. A pH meter was an electronic instrument used to measure the pH (acidity) of liquid. Atypical pH meter consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading.

3.5 Statistical analyses

Data analysis was done to determine the effect of different harvesting dates. The means were compared by analysis of variance, ANOVA One-Way using SPSS 16.0 statistic software. When differences were detected ($P<0.05$), Turkey test was used to compare the means between three harvesting dates.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Percentage of Weight Loss

Figure 4.1 showed the effects of different harvesting date on weight loss (%) value of Chili (*Capsicum annum* var. Kulai) during storage at ambient temperature 24.2±0.2^{0}C. The weight loss of fruits was determined by water loss in fruits during storage. Postharvest water loss of fruits and vegetables resulted in fruit softening, and reduced glossiness and shelf life (Kerstiens, 1996). In all harvesting dates, the weight loss was not significantly different (P>0.05) (Appendix A) from the control.

Figure 4.1, in all harvesting dates showed an increased in percent of weight loss (%) from day 0 until day 9. At the end of storage period (day 9), first harvesting date recorded a lower rate of weight loss (%) compared to the second and third harvesting. It means that first harvesting was successful in slowing down the ripening process were lower weight loss (%) on chili (*Capsicum annum* var. Kulai) was observed during storage at ambient temperature 24.2±0.2^{0}C. Lower weight loss (%) means low in water loss of this fruits, at prolonged storage period (Kerstiens, 1996).

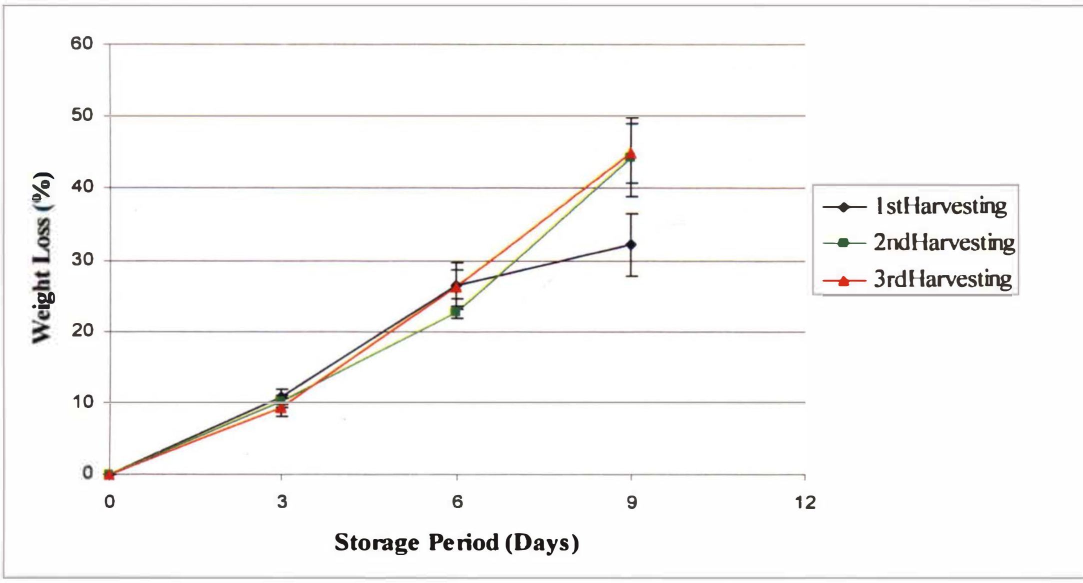

Figure 4.1: Effect of different harvesting date on the weight loss (%) value of the chili (*Capsicum annum* var. Kulai) storage at ambient temperature 24.2±0.2^{0}C. The vertical bars indicate the standard error.

4.2 Firmness

Texture has been used as an index of fruits quality in both fresh and processed fruits (Huxsoll et. 1989). Softening is due in large part to breakdown of the cell wall and middle lamellae induced by pectinases (Pilnik and Voragen, 1970), celluloses and the consequent loss of cell-wall integrity has been proposed as leading to the production of ethylene (C_2H_4) (Awad and Young, 1979; Solomos and Laties, 1973).

From data recorded, overall firmness of harvesting dates decreased gradually as the storage period was extended (Figure 4.2). Effect of different harvesting dates on shelf-life of Chili (*Capsicum annum* var. Kulai) during storage at ambient temperature 24.2±0.2^{0}C was as show in Figure 4.2. In all harvesting dates, the firmness values was not significantly different ($P>0.05$) (Appendix B) on day 0 until day 6. However on day 9, second harvesting date varied significantly ($P<0.05$) followed by third and first harvesting date. According to Sams (1999), texture of fruits depends on cellular organelles and biochemical constituents, water content, and cell wall composition; any external factor affecting fruits can modify the texture and change the final product quality.

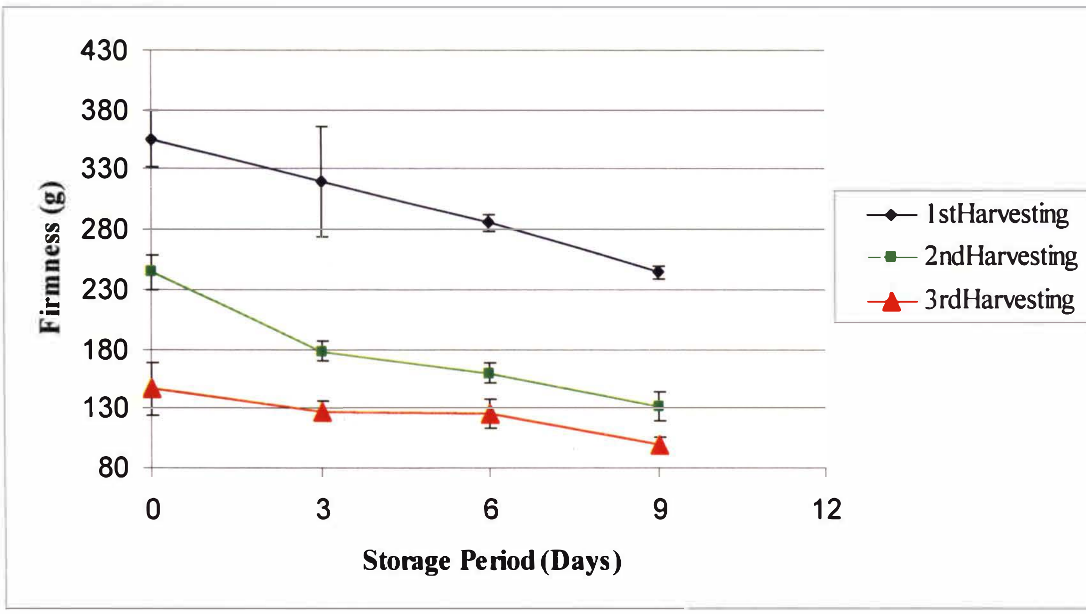

Figure 4.2: Effect of different harvesting date on the firmness value of the chili (Capsicum annum var. Kulai) storage at ambient temperature 24.2±0.20C.The vertical bars indicate the standard error.

4.3 pH

A pH meter is electronic instrument used the pH (acidity or basicity) of liquid. A typical pH meter consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading. pH is formally dependent upon the activity of hydrogen ions (H^+), but for very pure dilute solutions, the molarities may be used as a substitute with some sacrifice of accuracy. Figure 4.3; Appendix C, showed the effect of different harvesting date on pH value of Chili (*Capsicum annum* var. Kulai) during storage at ambient temperature 24.2±0.2^{0}C. pH value of the Chili (*Capsicum annum* var. Kulai) decreased in all the harvesting date over the storage, because all vegetable in green normally contain higher acidity compared with red chili. According to Wrigh, et al. (2003), titratable acidity and pH was decreased during storage. However, second harvesting varied significantly ($P<0.05$) compared with first and third harvesting (Appendix C).

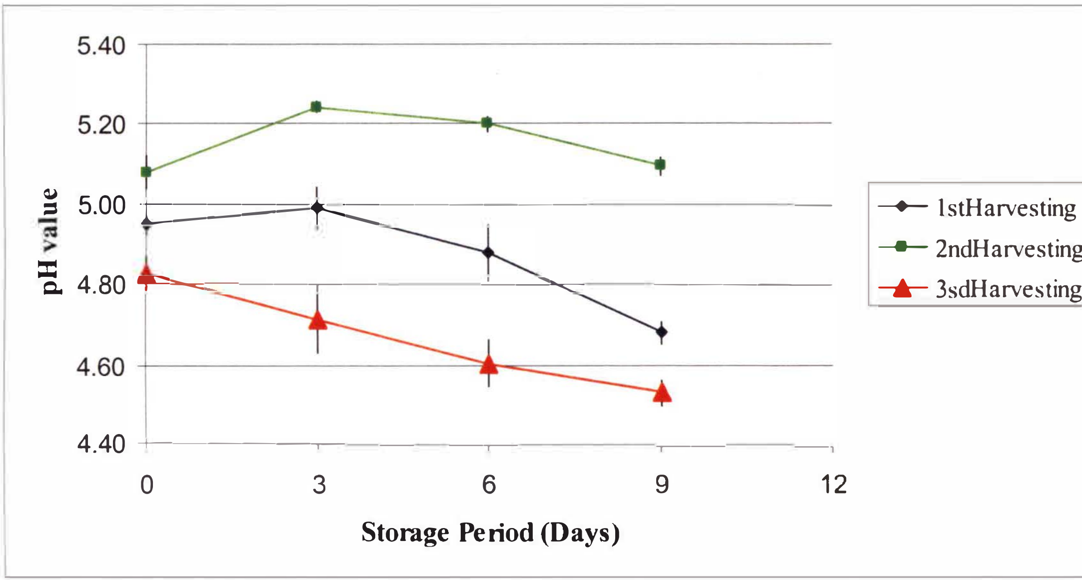

Figure 4.3: Effect of different harvesting date on the pH value of the chili (*Capsicum annum* var. Kulai) storage at ambient temperature 24.2±0.2^{0}C. The vertical bars indicate the standard error.

4.4 Color Change

Changes in color are the most apparent external symptoms of ripening. They are the result of chlorophyll degradation (disappearance of green color) and the synthesis of specific pigments. Color is a cosmetic of vegetable quality. It is the major factor in vegetables appearance, which also encompasses gloss; lesions and other attributes detected by visual evaluation of the product. In many cases, it cans serve as an index of physiological maturity, ripeness, or senescence and as indicator of physiological, mechanical, or pathological injury.

Color can be very useful measure of physiological state for post harvest physiologist who has knowledge in the production, harvest, and handling history of the vegetable. Color can also be a misleading indicator of vegetable quality in production, harvest, and handling operations and selected for appearance factor at a sacrifice of flavor or texture (Bartz and Brecht, 2003).

Regardless, color and other appearance factors are the primary means of evaluating vegetable quality within the post harvest handling system and in the consumer's purchase decision. A vegetable that looks unappealing is unlikely to be purchased and even less likely to be consumed.

A vegetable that has visual appeal but does not deliver on flavor or texture diminishes resale potential for the product. Thus, understanding of the effect of color on consumer acceptability and the means to accurately assess vegetable color are critical in any effort to maintain or enhance vegetable quality (Bartz and Brecht, 2003).

4.4.1 L value

The color changes in L* parameter was observed from day 0 to day 9, indicating a lightening of skin during storage. L* was the best parameter for determining the lightening of skin color. It indicates the lightness, vividness and deepness of the skin color.

Figure 4.4; Appendix D, showed the effect of different harvesting dates on color change (L value) of Chili (*Capsicum annum* var. Kulai) during storage at ambient temperature 24.2±0.2^{0}C. Among all of the harvesting dates, L value of chili (*Capsicum annum* var. Kulai) increases on until day 6, but decreases on day 9.

However, the L value of chili (*Capsicum annum* var. Kulai) in third harvesting most significantly different (P<0.05) between first and second harvesting dates on the day 9. The higher value of L* was recorded on third harvesting date, during 9 day storage at ambient temperature. The higher value of L* means that the more lightness, more vividness and the deeper of skin color.

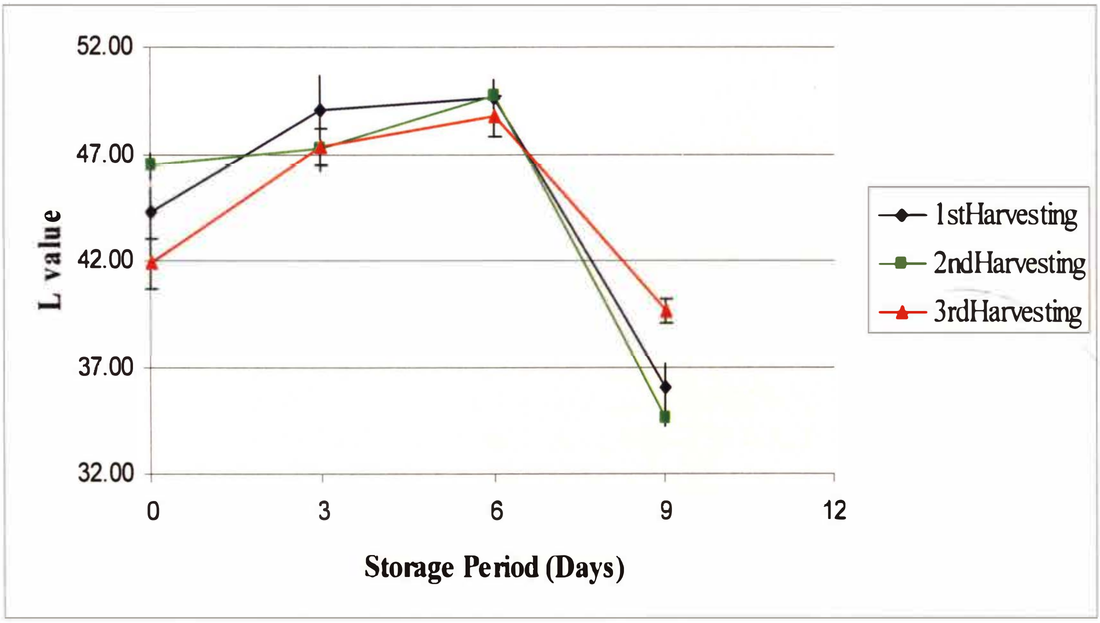

Figure 4.4: Effect of different harvesting date on the color change (L* value) of the chili (*Capsicum annum* var. Kulai) storage at ambient temperature 24.2±0.2^{0}C. The vertical bars indicate the standard error.

4.4.2 a* value

Figure 4.7 showed the effect of different harvesting date on color change (a* value) of Chili (*Capsicum annum* var. kulai) during storage at ambient temperature 24.2±0.2^{0}C. a* value refers to the changes from green color to red color in Chromaticity diagram (appendix H). The higher a* value means the skin color of chili getting more red and over ripening of the chili.

The second harvesting showed the most significant different (P>0.05) (highest value) in a* value compared with first and third harvesting date on the end of the storage (day 9) (Appendix E). During storage, the high rate of ethylene production and respiration occur in fruits harvested at the early green stage followed by those fruits at the greening and reddening.

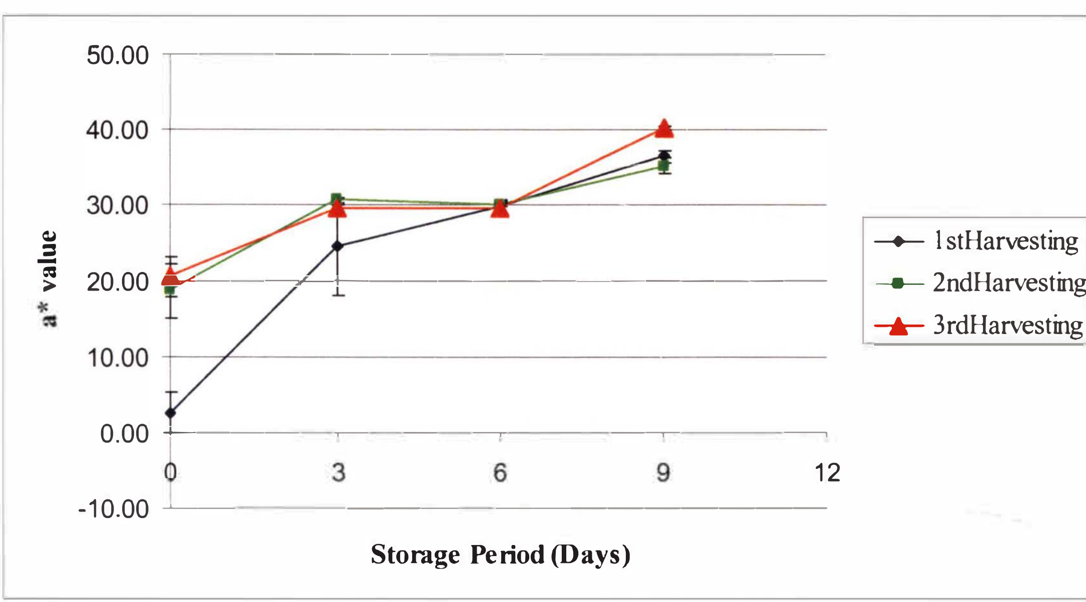

Figure 4.5: Effect of different harvesting date on color change (a* value) of the chili (*Capsicum annum* var. kulai) storage at ambient temperature 24.2±0.2^{0}C. The vertical bars indicate the standard error.

4.4.3 b* value

Positive b* value indicates the yellow and negative b* value indicated the blue color. Figure 4.8 showed the effect of different harvesting dates on b* value of Chili (*Capsicum annum* var. kulai) during storage at ambient temperature $24.2 \pm 0.2^{0}C$. The b* value (yellowness) in all harvesting dates increased gradually during storage period.

However, b* value of chili (*Capsicum annum* var. Kulai) on third harvesting was significantly different ($P<0.05$) (higher) between first and second harvesting dates on the end storage (day 9) (Appendix F). It means the third harvesting has been successful in slowing down the ripening process because it has been slowing the carotenoid changes into the lycopene (Salunkhe and Kadam, 1998).

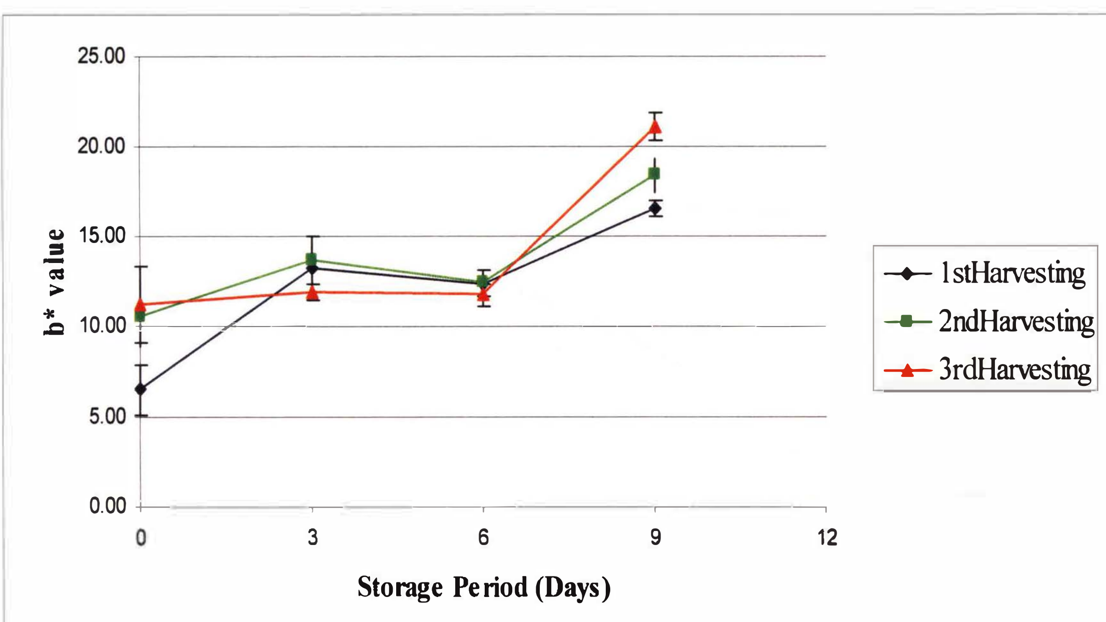

Figure 4.6: Effect of different harvesting date on color change (b* value) of the chili (Capsicum annum var. kulai) storage at ambient temperature 24.2±0.20C. The vertical bars indicate the standard error.

CAHAPTER 5

CONCLUSION

5.1 Conclusion and Recommendation for further study

In conclusion, result obtained from physical-chemical studies indicated that there were significant differences between different harvesting dates for some parameters tested over the storage period. Among harvesting dates, second harvesting could extend the storage life of chili's the longest at ambient temperature, 24 ± 0.2^0C and relative humidity of 70-75% with a minimum in physical characteristics such as color change (a*value), weight loss, and texture (firmness) compare with another harvesting dates. With respect chemical properties of chili's, the second harvesting date had minimally reduced to acidity (pH). So, second harvesting enabled to retain fresh quality of chili *(Capsicum annum* var. Kulai).

For the further study of different harvesting dates on Chili (*Capsicum annum* var. Kulai), other parameters can also be consideration such as pigment concentration, vitamin C, water contains, and etc. to help in understanding or the effect of different harvesting dates for prolong shelf-life of chili (*Capsicum annum* var. Kulai). The study can be done at more different harvesting dates, different variety for chili, different storage and relative humidity or can also be done with different chemical treatment in order to see the effects of those treatment in prolonging the shelf-life and maintaining the quality of chili during distribution chain before it reaches the end consumer in local or international market.

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APPENDICES

APPENDIX A: Means of weight loss (g) of three different harvesting dates Chili (*Capsicum annum*) during storage at ambient temperature 24±0.2^{0}C.

Harvesting Time	Storage Period (Days)			
	0	3	6	9
1	0 ± 0	10.797 ± 1.076^a	26.518 ± 2.022^a	32.150 ± 4.366^a
2	0 ± 0	10.208 ± 0.893^a	22.732 ± 0.843^a	44.296 ± 5.557^a
3	0 ± 0	9.290 ± 1.305^a	26.322 ± 3.308^a	44.874 ± 4.167^a

Means within columns with same letters are not significantly different (P>0.05)
Means within columns with different letters are significantly different (p<0.05)

APPENDIX B: Means of firmnes (g) of three different harvesting dates Chili (*Capsicum annum*) during storage at ambient temperature 24±0.2^{0}C.

Harvesting	Storage Period (Days)			
	0	3	6	9
1	355.482 ± 23.811^a	244.364 ± 45.737^a	146.728 ± 6.2842^a	87.980 ± 5.7196^a
2	319.840 ± 14.507^a	178.372 ± 8.455^a	128.052 ± 8.297^a	131.606 ± 12.4334^b
3	285.616 ± 22.054^a	166.134 ± 9.075^a	126.388 ± 12.441^a	99.366 ± 6.838^{ab}

Means within columns with same letters are not significantly different (P>0.05)
Means within columns with different letters are significantly different (p<0.05)

APPENDIX C: Means pH of three different harvesting dates Chili (*Capsicum annum*) during storage at ambient temperature $24±0.2^0C$.

Harvesting Time	Storage Period (Days)			
	0	3	6	9
1	4.906 ± 0.023^a	4.994 ± 0.052^b	4.884 ± 0.070^b	4.680 ± 0.029^b
2	5.084 ± 0.042^b	5.236 ± 0.016^c	5.196 ± 0.019^c	5.094 ± 0.026^c
3	4.834 ± 0.043^a	4.714 ± 0.085^a	4.596 ± 0.061^a	4.528 ± 0.033^a

Means within columns with same letters are not significantly different ($P>0.05$)
Means within columns with different letters are significantly different ($p<0.05$)

APPENDIX D: Means of color change (L value) of three different harvesting dates Chili (*Capsicum annum*) during storage at ambient temperature $24±0.2^0C$.

Harvesting Time	Storage Period (Days)			
	0	3	6	9
1	44.250 ± 1.180^a	49.085 ± 1.620^a	49.632 ± 0.798^a	35.972 ± 1.219^a
2	46.436 ± 0.591^{ab}	47.260 ± 1.090^a	49.680 ± 0.607^a	34.548 ± 0.364^a
3	41.856 ± 1.213^a	47.334 ± 0.822^a	48.760 ± 0.965^a	39.660 ± 0.569^b

Means within columns with same letters are not significantly different ($P>0.05$)
Means within columns with different letters are significantly different ($p<0.05$)

APPENDIX E: Means of color change (a* value) of three different harvesting dates Chili (*Capsicum annum*) during storage at ambient temperature 24±0.2^{0}C.

Harvesting Time	Storage Period (Days)			
	0	3	6	9
1	2.624 ± 2.714^a	24.402 ± 6.484^a	29.860 ± 0.943^a	36.522 ± 0.813^a
2	18.628 ± 3.638^b	30.666 ± 0.260^a	30.144 ± 0.335^a	35.286 ± 1.011^a
3	20.474 ± 2.647^b	29.616 ± 0.535^a	29.624 ± 0.733^a	40.355 ± 0.206^b

Means within columns with same letters are not significantly different (P>0.05)
Means within columns with different letters are significantly different (p<0.05)

APPENDIX F: Means of color change (b* value) of three different harvesting dates Chili (*Capsicum annum*) during storage at ambient temperature 24±0.2^{0}C.

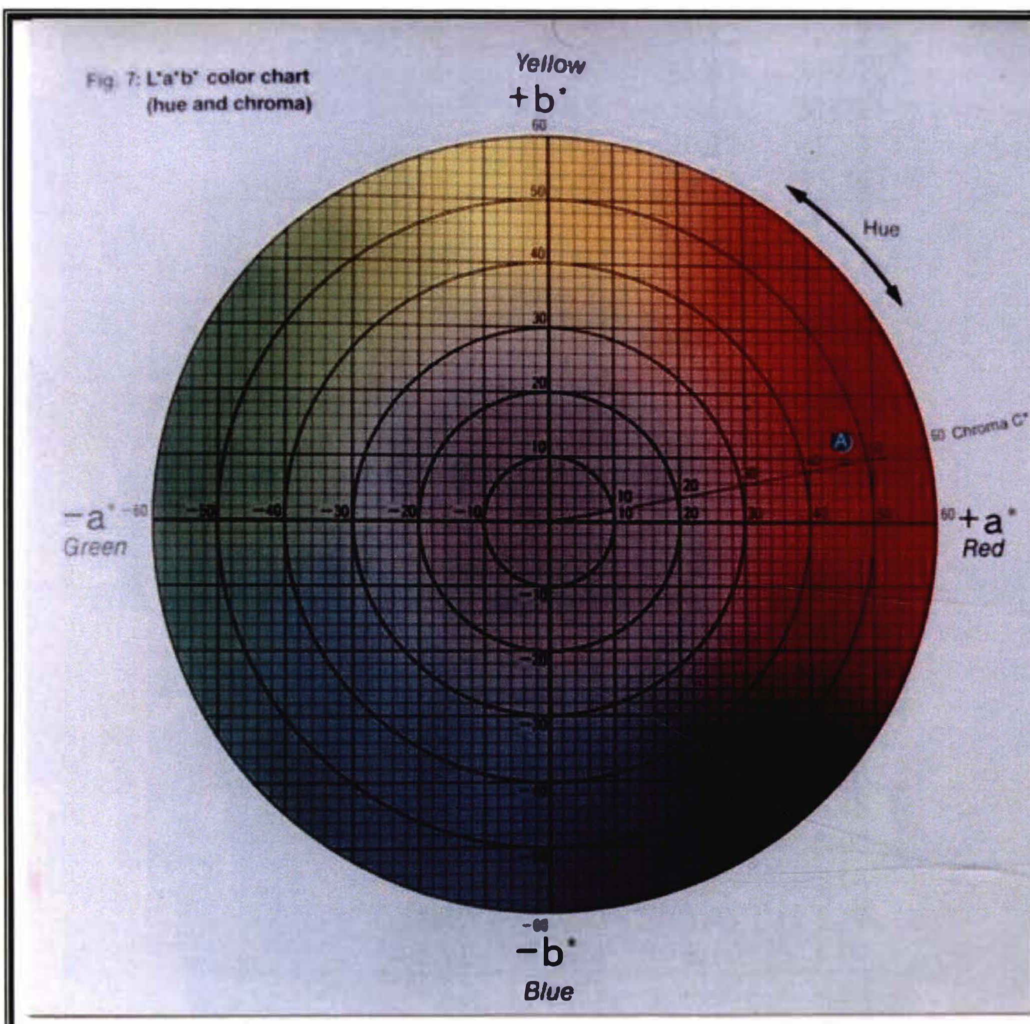
Harvesting Time	Storage Period (Days)			
	0	3	6	9
1	6.520 ± 1.416^a	13.220 ± 1.751^a	12.366 ± 0.695^a	16.558 ± 0.440^a
2	10.532 ± 1.594^a	13.712 ± 0.401^a	12.436 ± 0.149^a	18.398 ± 0.906^{ab}
3	11.254 ± 2.131^a	11.856 ± 0.463^a	11.758 ± 0.622^a	21.134 ± 0.805^b

Means within columns with same letters are not significantly different (P>0.05)
Means within columns with different letters are significantly different (p<0.05)

APPENDIX G: Harvesting Dates

Harvestig	Days (after flowering)
First	53
Second	60
Third	67

APPENDIX H: Chromaticity Diagram.



APPENDIX I: Raw data for weight Loss

	Storage Period (days)			
Harvesting	day0	day3	day6	day9
	0	9.15	22.49	20.36
	0	10.23	25.50	38.67
1	0	8.39	23.13	29.27
	0	11.76	27.78	27.33
	0	14.45	33.69	45.12
	0	9.09	20.69	50.00
	0	10.38	23.20	33.11
2	0	7.62	22.41	63.16
	0	11.05	25.67	34.90
	0	12.90	21.69	40.31
	0	8.55	31.82	32.52
	0	13.67	35.83	37.57
3	0	7.88	18.60	51.72
	0	5.95	20.22	48.80
	0	10.40	25.14	53.76

APPENDIX J: Raw data for pH

	Storage Period (day)			
Harvesting	day0	day3	day6	day9
	4.90	4.99	4.87	4.74
	4.91	4.87	4.96	4.65
1	4.86	5.12	5.07	4.68
	4.87	4.89	4.88	4.59
	4.99	5.10	4.64	4.74
	4.98	5.20	5.19	5.15
	5.15	5.26	5.15	5.03
2	4.99	5.28	5.23	5.06
	5.19	5.20	5.25	5.16
	5.11	5.24	5.16	5.07
	4.82	4.65	4.40	4.53
	4.80	5.03	4.70	4.60
3	4.90	4.54	4.54	4.46
	4.70	4.61	4.60	4.45
	4.95	4.74	4.74	4.60

APPENDIX K: Raw Data for Firmness

	Storage Period (days)			
Harvesting	day0	day3	day6	day9
	406.83	423.23	130.57	81.00
1	405.81	227.60	139.80	98.90
	279.05	211.13	152.27	72.60
	345.03	188.73	143.33	103.30
	340.69	171.13	167.67	84.10
	304.80	205.63	124.63	115.80
	280.91	169.03	157.47	95.30
2	323.33	154.70	111.13	168.60
	369.39	177.90	132.80	143.70
	320.77	184.60	114.23	134.63
	264.39	155.47	170.30	94.10
	370.67	141.77	124.70	90.00
3	279.51	156.23	98.90	87.13
	243.73	194.93	106.77	100.37
	269.78	152.27	131.27	125.23

APPENDIX L: Raw Data for Color Change (L value)

	Storage Period (days)			
Harvesting	day0	day3	day6	day9
	43.95	43.95	50.69	38.48
	42.91	52.08	51.99	31.71
1	48.86	52.40	49.39	35.82
	43.15	50.03	48.73	38.23
	42.38	46.78	47.36	35.62
	45.13	48.70	51.14	35.42
	47.69	43.12	49.25	33.94
2	46.02	49.27	47.63	35.21
	47.98	47.97	50.60	33.51
	45.36	47.24	49.78	34.66
	42.45	46.10	46.29	41.32
	39.39	50.17	52.18	40.62
3	39.18	45.77	48.45	38.52
	42.48	48.19	48.94	38.47
	45.78	46.44	47.94	39.37

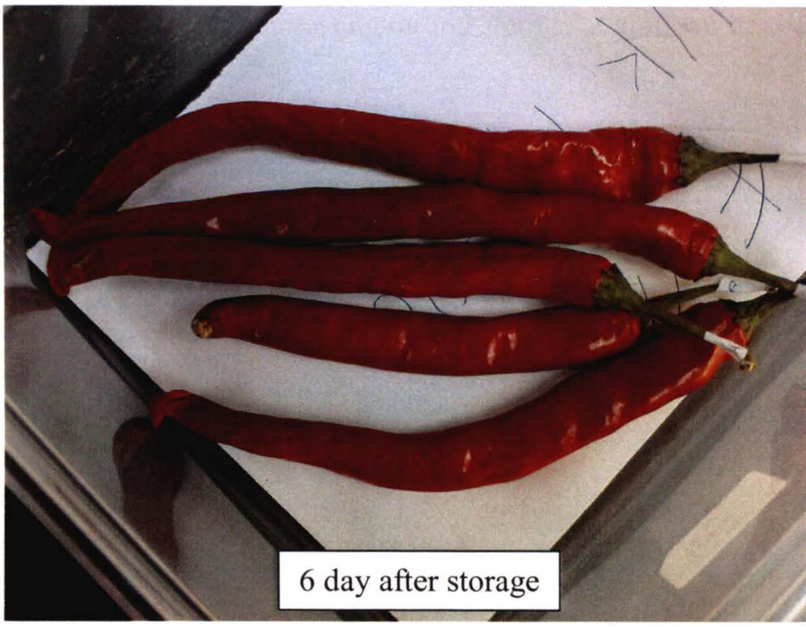
APPENDIX M: Raw Data for Color Change (a* value)

	Storage Period (Days)			
Harvesting	day0	day3	day6	day9
1	-2.96	-1.47	29.55	37.26
	-1.38	32.38	30.83	33.60
	9.71	29.58	29.38	36.24
	8.71	30.35	32.64	37.04
	-0.96	31.17	26.90	38.47
2	20.21	29.86	29.75	32.86
	24.68	31.48	30.08	37.14
	26.31	30.71	30.30	36.12
	6.01	30.77	31.37	37.43
	15.93	30.51	29.22	32.88
3	11.52	30.97	30.05	41.08
	23.66	29.95	28.97	40.35
	18.63	29.68	32.18	40.35
	21.33	27.68	29.13	40.20
	27.23	29.80	27.79	39.81

APPENDIX N: Raw Data for Color Change (b* value)

	Storage Period (Days)			
Harvesting	day0	day3	day6	day9
1	4.03	6.46	12.98	16.85
	5.16	15.15	13.69	15.15
	8.91	13.64	11.79	16.13
	10.81	14.40	13.46	16.87
	3.69	16.45	9.91	17.79
2	12.85	13.13	12.09	17.09
	14.32	14.91	12.39	19.46
	11.77	13.53	12.38	19.55
	5.72	14.31	12.99	20.38
	8.00	12.68	12.33	15.51
3	19.26	13.51	12.10	22.54
	9.17	11.62	11.35	23.36
	7.64	11.50	13.85	18.90
	8.27	10.68	11.47	20.27
	11.93	11.97	10.02	20.60

APPENDIX O: First harvesting during storage at ambient temperature.



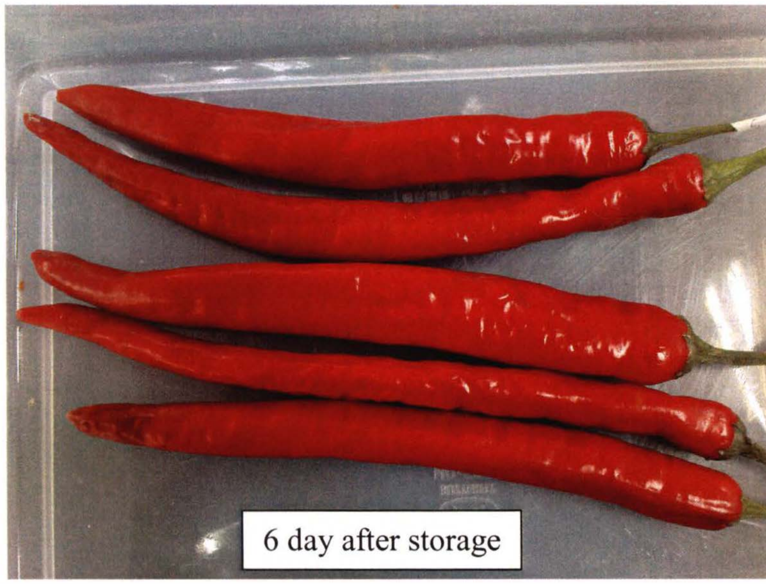
6 day after storage

9 day after storage

APPENDIX P: Second harvesting during storage at ambient temperature.

On the day of harvest (day 0)

3 day after storage



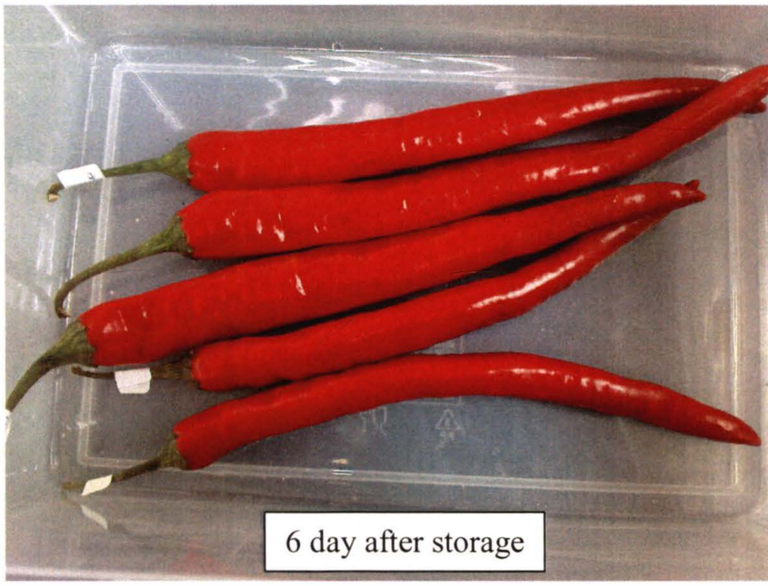
6 day after storage

9 day after storage

APPENDIX Q: Third harvesting during storage at ambient temperature.


On the day of harvest (day 0)


3 day after storage


6 day after storage


9 day after storage

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EFFECT OF DIFFERENT HARVESTING DATES ON SHELF-LIFE OF CHILI, CAPSICUM ANNUM VAR, KULAI - NOOR AIN BINTI MOHD FAUDZI