EFFECT OF DIFFERENT PRE-COOLING TIME ON POSTHARVEST QUALITY OF BANANA

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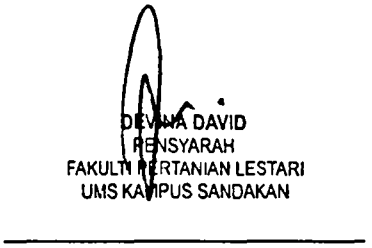

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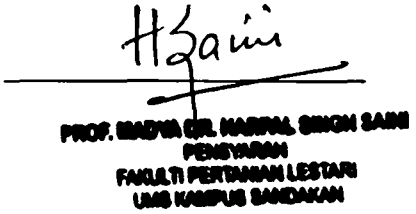

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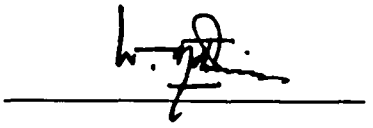

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ABSTRACT

A lab experimentwas conducted at Faculty of Sustainable Agriculture, University Malaysia Sabah, Sandakan to determine the effect of different precooling duration on the postharvest quality of banana, more precisely the *Musa acuminata* or Pisang Lemak manis. The banana was bought from Kampung Nelayan, Sandakan Batu 10. The banana washarvested 11 a.m. at the morning, andpackaged in a cool box before send to lab. Then banana was unpacked and expose to different treatment. The experiment design was CRD using different treatment such as 0 Cooling Time (CT), 1/8 CT, 1/4 CT, and 1/2 CT. After pre-cooling process, the banana samples were kept in controlled environment of 10 -15°Cfor 4 weeks of storage duration. The replicates of each treatment was taken weekly for analysis ofweight loss, firmness, skin colour L*C*h°, SSC, titratable acid, pH and moisture content after storing in cold room.The results were analyzed using IBM SPSS Statistic 21, and 2-Way ANOVA test was run to test the significance effect of 2 factors. The result show that generally the different pre-cooling time did not affect physical quality significantly, but rather on the chemical qualities especially the SSC and pH of *M.acuminata*. The result did not suggest the best cooling time but post hoc test had differentiated the effect with or without pre-cooling.

KESAN REKA BENTUK PRA-PENYEJUKAN TERHADAP KUALITI LEPAS TUAI PISANG

ABSTRAK

Suatu kajian telah dibuat tentang jangka masa pra-penyejukan terhadap kualiti lepas tuai *M. acuminata* ataupun pisang lemak manis d iFaculty Pertanian Lestari, Universiti Malaysia Sabah, Sandakan. Pisang tersebut telah dibeli daripada Kampung Nelayan, Sandakan Batu 10.Pisang itu dituai pada 11 pagi, disimpan dalam peti sejuk sebelum dihantar ke makmal.Selepas itu pisang dikeluarkan dan diberi rawatan masing-masing. Kajian ini telah dibuat menggunakan reka bentuk eksperimen CRD dengan 0 Cooling Time (CT), 1/8 CT, 1/4 CT, and 1/2 CT. Selepas proses pra-penyejukkan, sampel pisang disimpan dalam persekitaran terkawal yang bersuhu 10 -15°C selama 4 minggu. Replikasi sampel dikeluarkan setiap minggu untuk analysis kehilangan berat, kepejalan buah, warna kulit L*C*h°, kandungan pepejal larut, titratable acid, pH dan kandungan air. Keputusan dianalisis dengan IBM SPSS Statistic 21, dan 2-Way ANOVA test untuk membezakan 2 faktor ini. Keputusan makmal menunjukkan secara keseluruhannya tiada perbezaan seerti untuk kualiti fizikal tetapi ada perbezaan seerti untuk kualiti kimia terutamanya kandungan pepejal larut dan pH *M.acuminate.* Keputusan ini tidak menunjukkan mana-masa penyejukkan terbaik, tetapi kajian post hoc dapat membezakan kesan penyejukkan dan tanpa pra-penyejukkan terhadap sampel pisang.

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LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

%	Per cent
°C	Degree Celsius
mg	Milligram
IU	International unit
°Brix	Degrees Brix
cm^2	Square Centimeter
kg	Kilograms
mm	Millimeter
ppm	Parts per million
RH	Relative Humidity
SSC	Soluble Solid Content
Kg F	Kilogram Force
L*	Lightness
C*	Chroma
h°	Hue

CHAPTER 1

INTRODUCTION

1.1 Introduction

According to fruit classification, banana is considered as a berry botanically (Elhadi, 2011). Modern bananas and plantains came from Southeast Asia and Western Pacific regions. It is estimated about 100 million people worldwide consuming them as main energy source or treated as their banana as staple food (Rowe, 1981). Banana is well known to have good taste, provide quick energy and protect us against muscle cramp. Bananas not only can be eaten raw, it can be used to cook whether it is ripened or not, and it can also processed into other products for consuming purpose. The distinct flavor of banana come from amyl esters while fruity flavor and aroma came from butyl ester, but other component such as aldehydes, alcohols and ketones also related to the flavor and their production continue to increase during ripening (Tressl and Jennings, 1972).

Estimation of world banana production has risen from 20 million tonnes in 1960 to 95 million tonnes in 2009, and India by far is the largest producer while Ecuador is the largest exporter (Elhadi, 2011). According to Elhadi (2011), some countries especially in Latin America are very efficient in producing banana, having advance infrastructure and maximizing their yield with optimum inputs.

Based on statistic, banana is the second most widely cultivated fruit in Malaysia, covering 33,584 hectares of the total fruit production area of 297,860 hectares which is

about 10% of cultivated areas, and total production of 535,000 tonnes (Roff *et al.*, 2012). And due to its importance for domestic and export, Malaysia government had place banana under one of the 15 types of fruits to be prioritized for development underthe National Agriculture Policy.The most popular local banana grown for commercial purpose are the Pisang Berangan, Pisang Mas and Pisang Rastali, while the varieties cultivate for cooking and secondary uses are Pisang Raja, Pisang Nangka, Pisang Abu, Pisang Awak and Pisang Tanduk (Abd Shukor *et al.*, 2000). According to Shukor, there is anincrease in the export of banana ranging from 20000-35000 tonnes per year from the years 1989 to 2009. However, there are also small amount of imports between 40-350 tonnes of banana annually. This shows that international trade of banana in Malaysia is still positive. The domestic consumption and demands of banana is increasing over the years and possible factor contribute to these demands are population increase in country, greater living standard and also health concern of public these days. The present consumption per capita of banana is about 22kg.

Banana is climacteric fruit but it does not ripen uniformly in the field (Yadav, 2007). Therefore, some of the farmer's practices are harvesting while they are green and fully mature. Due to its climacteric properties, it has relatively short shelf life which is about 1 week. There are no visible defects on external appearance of green mature fruit, but after ripening there are consequence symptoms show externally and internally as well. Ripening of banana, same like other climacteric fruit were cause by respiration but the metabolic events that involve in climacteric and factors regulating these processes are not properly understood and had been intensively researched (Seymour *et al.*, 1993). As far as we know, ethylene and temperature play important role for the ripening process of banana. Due to the perishability of these fruit, we need to have proper post-harvest handling process to extend the shelf life to avoid unnecessary loss. Patil (1998) stated that up to 30 to 40% of banana go to post-harvest loss due to improper handling. Beside physical losses, these improper handling will also lead to a serious quality loss. Banana is susceptible to chilling injuries, and yet heat can also speed up the respiration process and greatly reduce the shelf life of banana. Therefore temperature play important role in keep the postharvest quality of banana.

Heat can lead to multiple problems such as mixed-ripe fruit (Robinson, 1996). Mixed-ripe fruit refers to a condition that harvested fruit ripen prematurely and consequently spoil the whole carton of fruit by stimulating rot and premature ripening of other bananas. Robinson stated that there are many factors contribute to this condition but one of the main factors is heat stress on fruit during and after harvesting process. So, high temperature should be avoided during process of harvesting, packaging and storage to slow down the physiological breakdown process of the fruit. If the harvested fruit is to transport in long distance, proper pre-cooling need to be done and refrigerated condition must be suited to crop species in order to maintain the quality until it reaches the market. Any postharvest job should be done at cool temperature, and the cartons must be pre-cooled to 13°C. And harvesting if possible, it is better to perform at morning where temperature is relatively low and absence of direct sunlight. The Sun will also heat up the atmosphere by its radiation. In addition to that, pack houses in hot areas should build to insulate heat especially on the roof and field heat should be removed before carry on other processes.

About 75% of field heat of harvested fruit came from direct sunlight exposure (Hardenburg *et al.*, 1986). Therefore technique such as pre-cooling is applied to remove those heats. Pre-cooling is able to maximize storage life of many types of crops and reduce losses during their marketable life, but it is important to keep them at temperature above the point which will result in chilling injuries (Thompson, 2003). Susceptibility of crop towards chilling injuries depends on factors such as time exposed in pre-cooler, crop cultivar and environment of crop growing. There are many forms of pre-cooling methods available nowadays, each type serves its own purposes and situation. Examples of pre-cooling method are top icing, room cooling, forced air-cooling, hydrocooling, vacuum cooling, and etc. In this research, the main concern is more about the hyrocooling methods. The principle of hydrocooling is to spray or water bath crop products with chilled water, the chill water will remove heat from those products upon contact. The limitation of this method is we cannot apply it on crops which are sensitive to wetting, because it will promotes the growth of decay organism. The steps in hydrocooling had to be done correctly to prevent undesirable results. We have to determine the suitable duration of exposure to chill water and water temperature to ensure proper cooling.

1.2 Justification

Hydrocooling has been known to be able to apply on almost but not all type of horticultural crops. It is suitable for crops that need to be washed after harvest, banana has fit into this criteria. A lot of research has done on ethylene treatment to synchronize the ripening of banana after shipping transport, but little had done on precisely how to remove field heat using hydrocooling method. As mentioned earlier, improper postharvest treatment can lead to losses and decrease shelf life, prolonged exposure to pre-cooling will also result in negative effect on fruit quality. So, the purpose of this study is to find out the effect of different pre-cooling time on the post-harvest quality of banana.

Besides that, hyrocooling is one of the postharvest management that can add value to the horticultural crops. In certain country such as United States, hydrocooling is one of the Standard Operating Procedure (SOP) to manage harvested fruit. Hydrocooling not necessarily must be inside a handling house, but it can also be build inside a transporting truck where they send the harvested fruit into distance market. About the adding value of crop, means that certain buyer willing to pay more if the crops are handled by hydrocooling process. This is because it can help to clean the fruit, and preserve the chemical quality of fruit. Therefore it has necessity to hydrocooled product rather than direct storage.

Due to lacking of information on pre-cooling time of banana and its effect on postharvest quality, so the purpose of this study is to find out quality of *Musa acuminata* affected by duration of pre-cooling. The postharvest quality includes its physical appearance and its physiological properties.

1.3 Research Objective

1) To determine the effect of different pre-cooling time and storage duration to *Musa acuminata*cv. Pisang Lemak Manis (PLM)using hydrocooler

1.4 Hypothesis

H_0: The duration of pre-cooling will not affect postharvest quality of *M. acuminata*

H_A: The duration of pre-cooling will affect postharvest quality of *M. acuminata*

CHAPTER 2

LITERATURE REVIEW

2.1 *Musa* sp.

Banana belongs to the family of genus *Musa*, or the family Muscaeae. There are 2 types of native species which is *M. acuminata* and *M. balbisiana*. Malaysia is primary origin of M. acuminata and spread to other region, while another variety *M. balbisiana* origin from India and Burma. This 2 native create varieties of cultivar through process of natural hybridization, mutation and polyploidy breeding. It is believed that about 1000 varieties already presence in the world and they are sub-divided into 50 groups (Yadav, 2007). Banana are available all year long, growing and export within 30 degree on either side of the equator.

Banana is monocotyledon in nature, herbaceous plant that bears large size of leaves on a sheath consisting of clasping leaf stalk. The top portion that made up sheath of leaves is known as pseudo-stem, which is found to be swollen at the base area. The top of sheath is contracted into petiole and the lamina is extension of margin of midribs. The pseudo-stem produce fruit only for once and therefore it is cut-off after fruiting. Its inflorescence end is called pendant, and some people used it to cooking dishes. The fruit itself is called fingers, each cluster of them (also called hand/ bunch) had about 12 fingers. The fruit itself is seedless and it reproduces by vegetative parthenocarpy.

*M. acuminata*is a perennial plant that can grow up to 3 meters of height. In the family of *M.acuminata*genome AA, there many type of variety including pisang mas, pisang lemak manis, and pisang berangan. This experiment will use pisang lemak manis, which is also under the family of *M.acuminata.*

2.2 Composition and Uses

Banana fruit contain rich source of starch and the most important component of them are amylose and amylopectin (Fatimah, 2011). The sugars content in banana pulp is 1.3% in unit of total dry matter but will rise up to 17% when ripen. The fat content of ripen banana is less than 0.5% and total protein is about 3.5%. Banana also can be treated as good source of vitamin A, B, C and minerals

Table 2.1 Nutritional value of banana (per 100g raw edible portion)

Constituents	**Nutritional value per 100g**
Water (g)	74.26
Protein (g)	1.03
Fat (g)	0.48
Carbohydrate (g)	23.43
Calcium (mg)	6
Iron (mg)	0.31
Potassium (mg)	396
Sodium (mg)	1
Vitamin C (mg)	9.1
Thiamin (mg)	0.045
Riboflavin (mg)	0.100
Niacin (mg)	0.540
Vitamin A (IU)	81

Source: Fatimah, 2011

The plant itself has many uses, not only for its fruit but other part as well. It's bunches of leave are used in ceremony such as wedding, festivals and some worship events. The fruit are mainly for direct consuming or can be used for making cuisines. The part that can be used for cuisines are the central core of pseudostem and male bud of banana. Products that commonly found to be made banana includes chips, soft drinks, alcohol, vinegar, ice-cream, powder, jam and etc.

The benefit that banana can give are many, such as high K concentration that can prevent muscle cramp for sportsman. The banana contain low amount of sodium, low fat and cholesterol so it is useful in managing patient that has high blood pressure and cardiovascular diseases. Besides that, bananas are free from substance that will stimulate production of uric acid, so it is safe consume for patient with gout or arthritis. Its low lipid properties also good for obese people which thinking of a diet program.

2.3 Banana fruit Postharvest Quality Characteristics

2.3.1. Soluble Solid Concentration

Sugars are the major soluble solids that can be found in fruit juice. Other soluble materials include organic and amino acids, soluble pectins, etc. Soluble solids concentration in the unit of Brix can be determined by using a hand refractometer. This instrument measures the refractive index, which indicates how much a light beam is divert when it passes through the fruit juice. As the banana is ripening, there is increase in sugars as starch is converted to soluble solids. The SSC of banana is often believed to be linked to consumer taste preference. And generally, fruits above 12 % Brix are considered more acceptable to consumers (McGlone and Kawano, 1998).

2.3.2. Titratable Acidity

Titratable acidity is one of the parameter to measure the maturity level of fruit, it is also involve in the perception of sweetness and sourness of fruit. The concept of this

method is to measures the concentration of titratable hydrogen ions/ acids contained in the fruit juice samples by neutralization with strong base solution. The acid will be developed during the course of maturity and result in reducing pH value.

2.4 Post-harvest Physiology

2.4.1. Ethylene Production and Respiration

Ethylene level in unripe banana is relatively low, increase over ripening stage together with the rate of respiration (Burg and Burg, 1965). Ethylene peak production normally reached while the rate of respiration is still increasing. Anyways, ethylene is known to intimately involve in the initiation of banana ripening. Exposure ethylene to unripe banana will shorten preclimacteric period, while 24 hours of ethylene exposure will induce prompt initiation of ripening. Most of the fruits including bananas show climacteric properties after harvest, but when they are left on plant, they remain unripen for longer period of time (Seymour, 1993). These suggest that while attach to the plant, there is inhibitory factor that supply to plant that regulate the phase of ripening (Burg and Burg, 1965).

2.4.2. Carbohydrate Metabolism

Starch comprise of 20% to 25% of total fresh unripe bananas (Seymour, 1993). This is shown by reduction of starch content from 20-23% to 1-2% after ripening process (Robinson, 1996). During ripening process, there is rapid degradation of starch into sucrose, glucose and fructose. According to Robinson, the sugars also increase into similar proportion. Palmer (1971) had shown that trace of maltose also present in the ripened banana. In the pulp, the highest amount of sugar is sucrose at the beginning of ripening process, this sugar will later on lead to accumulation of glucose and fructose (Areas and Lajolo, 1981). The peel tissues also contain about 3% of starch, and it show similar changes during ripening. Research from Lizana (1976) had shown that at temperature of 40°C, sucrose formation was suppressed while formation of other such as sugar glucose and fructose still observe. This means that behavior of

carbohydrate metabolism can be affected by elevated temperature during ripening process, which is also another crucial point to support this research that high temperature can affect quality of bananas.

2.4.3. Pigment Changes

During ripening process, the peel colour of banana changes from dark green to bright yellow. This is due to destruction of chlorophyll and this process will wil slowly reveal the carotenoid found in the unripe peel. Studies of Gross and Flugel (1982) shown that there is actually changes of pattern of carotenoid in banana peel during ripening process as well. Their data show that total carotenoid content is reduce during early stages of ripening follow by an increase at yellow-green to yellow stages. However, this process can easily be controlled by temperature of 16°C to 18°C, while normal ripening can be induced by subjecting them to ambient temperature of 25°C.

2.4.4. Cell Wall Changes

The softening of fruit is highly related to the changes of cell wall structure (Seymour, 1993). In the case of banana, the changes of fruit texture are most probably resulting from alteration in cell wall structure as well as starch degradation. Jarvis *et al.* (1988) research on pectin content of non-lignified monocot cell walls and reported that bananas had wall pectin content comparable to other dicot. The changes in pectin structure during ripening process show that pectin degrading enzyme might be activated in these cell walls. Markovic *et al.* (1975) had identified enzymes polygalacturonase in the ripening bananas. Although there are also other enzyme found to be degrading cell wall components.

2.4.5. Phenolic Compounds

Banana fruit tissue, especially the peel contain high amount of phenolics, such as 3,4-dihydroxyphenylethylamine and 3,4-dihydroxyphenylalanine. These compounds are

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