THE EFFECT OF HYDROCOOLING TIME CALCULATED AT DIFFERENT FRUIT LAYER AND STORAGE DURATION TO POSTHARVEST QUALITY OF SABA BANANA (*Musa balbisiana*)

NIK NUR AKLILI BINTI NIK YAACOB

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JUDUL: THE EFFECT OF HYDROCOOLING TIME CALCULATED AT DIFFERENT FRUIT LAYER AND STORAGE DURATION TO POSTHARVEST QUALITY OF SABA BANANA (*Musa balbasiana*)

IJAZAH: IJAZAH SARJANA MUDA SAINS PERTANIAN DENGAN KEPUJIAN HORTIKULTUR DAN LANDSKAP

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1. Dr. Jupikely James Silip

SUPERVISOR

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ABSTRACT

A study has been conducted at Postharvest Laboratory in Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan to determine the effect of hydrocooling time calculated at the different fruit layer and storage duration to the postharvest quality of Saba banana (*Musa balbasiana*). Fully matured unripe Saba banana has been taken at the Saba banana plot in Faculty of Sustainable agriculture has been pre-cooled using the hydrocooling method at ½, ¼, 1/8 and 0 cooling time (CT) at different fruit layer using (FL) a portable hydrocooler and storage duration (SD) at 11±2°C for 0,1,2,3,4 and 5 weeks. The experimental design was factorial arrangements of treatments (4 cooling time x 4 fruit layer site x 6 storage duration) with three replications of banana fingers. The data has been analysed using SAS statistical computer package Version 9.4 and two-way analysis of Variance (ANOVA) has been carried out to determine significant effect between three factors. Duncan's multiple range test (DMRT) was performed for mean comparison. Based on the results, the hydrocooling times calculated at different fruit layer (FL) and storage for five weeks has an effect to postharvest quality of Saba banana. Limit of acceptable visual appearances at irrespective fruit layers were at week four of storage time. Advantage of precooling application are delay conversion of starch to sugar resulting of lower soluble solid and higher firmness reading and lowers weight loss during storage. Recommended hydro-cooling time is minimum at 1/8 cooling time and maximum at ¼ cooling time. This is due to slower weight loss process (13.37g), slower decreasing of firmness (2.28 kg F) and slower conversion of total soluble solid value (6.10 °Brix). Result of this study are not recommend to monitor the cooling time at core due to fast ripening response but at skin and flesh layer are recommended. This is due to slower decreasing of firmness (2.39 kg F) and slower conversion of total soluble solid (5.88 °Brix).

KESAN PENGIRAAN MASA PRA-PENYEJUKAN AIR DINGIN PADA LAPISAN BUAH YANG BERBEZA DAN TEMPOH PENYIMPANAN KUALITI PENYIMPANAN BUAH PISANG SABA (Musa balbisiana)

ABSTRAK

Satu kajian telah dijalankan di Makmal Lepas Tuai di Fakulti Pertanian Lestari, Universiti Malaysia Sabah, Sandakan untuk menentukan kesan masa penyejukan di lapisan suhu buah dan tempoh penyimpanan yang berbeza untuk kualiti lepas tuai pisang Saba (Musa balbasiana). Pisang Saba yang matang telah diambil di plot pisang Saba di Fakulti Pertanian Lestari telah disejukkan dengan menggunakan kaedah penyejukan air sejuk pada ½, ¼, 1/8 dan 0 masa penyejukan yang berbeza tempat pengambilan lapisan buah menggunakan penyejuk air dingin mudah alih dan disimpan pada 11 ± 2°C untuk 0,1,2,3,4 dan 5 minggu. Reka bentuk eksperimen adalah perkiraan faktorial rawatan (4 masa penyejukan x 4 lapisan suhu buah x 6 tempoh simpanan) dengan tiga ulangan jejari pisang. Data telah dianalisis menggunakan pakej komputer statistik SAS Versi 9.4 dan analisis dua hala Varians (ANOVA) telah dijalankan untuk menentukan kesan yang signifikan antara tiga faktor. Ujian pelbagai ujian Duncan (DMRT) dilakukan untuk perbandingan min. Berdasarkan hasil yang diperhatikan, masa penyejukan yang dikira pada lapisan buah yang berlainan (FL) dan tempoh penyimpanan mempengaruhi kualiti lepas tuai pisang Saba. Had penampilan visual boleh diterima di lapisan buah-buahan tidak kira berada di empat minggu daripada masa penyimpanan. Kelebihan aplikasi precooling adalah kelewatan penukaran kanji kepada gula yang menyebabkan bacaan tegangan yang lebih rendah dan mantap yang lebih rendah dan menurunkan berat buah semasa simpanan. Waktu penyejukan hidro yang dicadangkan adalah minimum pada 1/8 masa penyejukan dan maksimum pada masa penyejukan ¼. Ini disebabkan oleh proses penurunan berat buah yang lebih perlahan (13.37g), penurunan ketegangan yang lebih perlahan (2.28 kg F) dan pemperlahankan penukaran nilai pepejal larut (6.10 °Brix). Hasil kajian ini tidak mencadangkan untuk memantau masa penyejukan pada teras buah disebabkan oleh tindak balas peranuman pantas tetapi pada lapisan kulit dan isi disyorkan. Ini disebabkan oleh penurunan ketegangan yang lebih perlahan (2.39 kg F) dan penukaran yang lebih perlahan daripada pepejal larut (5.88 °Brix).

TABLE OF CONTENT

Content **Page**

CHAPTER 3 METHODOLOGY

CHAPTER 4 RESULTS

CHAPTER 5 DISCUSSION

LIST OF TABLES

LIST OF FIGURE

LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

ANOVA	Analysis Of Varience
C*	Chroma
CT	Cooling Time
DMRT	Duncan Multiple Range Test
FL	Fruit Layer
h°	hue
Kg F	Kilogram Force
L*	Lightness
NaOH	Sodium Hydroxide
NS	Not Significance
SD	Storage Duration
TSS	Total Soluble Solid
VA	Visual Appearance
WL	Weight Loss
°Brix	Degree Brix

LIST OF FORMULAE

CHAPTER 1

INTRODUCTION

1.1 Background

Banana comes from genus *Musa*. It is a member of the family Musaceae and can grow up to 15 m tall (Constantine, 2001). Banana is climacteric fruit, monocotyledons and the fruit is a simple berry fruit (Yahia, 2011). Bananas are world's fourth most important food crops after rice, wheat and maize (INIBAP, 2000). Millions of small-scale farmers in Africa, South Asia, and Northern Latin America grow the fruit for consumption or local market. Total world production of sweet and plantains bananas in 2005 was over 100 million tonnes (FAO, 2006).

In Malaysia, based on statistic, banana is the second most widely cultivated fruit. The fruit acreage covers 33,584 hectares of the total production area of 297,860 hectares which is about 10% of cultivated areas, and total production is 535,000 tonnes (Noor, *et al.,* 2012). Malaysian government had place banana under one of the 15 types of fruits to be prioritized for development due to its importance for domestic and export.

Banana can fall into two sub-groups; the sweet or dessert banana and plantain which is also called as cooking bananas. Sweet or dessert banana is usually eaten raw at maturity belongs to the genomic group *acuminata* cultivars (AAA). Meanwhile, cooking banana are starchy types which are cooked before eating and constitute an important item in the diet of people in places where there is a shortage of staple food are categorically known as *balbisiana* cultivars (BBB).

The most common cooking banana cultivar with commercial importance in Malaysia is Saba banana which is grown throughout Malaysia. It has the largest and tallest stem attaining a height of four meters. Saba banana bunches are comprised with 8 to 16 and each hand consist 12 to 20 fingers. The fruits are shorts, stubby and highly angular. The skin is thick and yellow when ripen. The pulp is creamy white, fine textured with well-developed core and occasional seeds (Obiageli, *et al.,* 2016).

Good temperature management is one of the important factors in delaying fresh produce from deterioration. Rapid cooling and maintenance of proper temperatures are both critical. Rapid cooling after the harvest which is commonly known as 'pre-cooling' and it is primarily designed for rapid removal of field heat (Brosnan and Sun, 2001). Brosnan and Sun (2001) reported that it is critical only to cool the product along the distribution chain and it must be cooled as quickly as possible after harvest in order to ensure the good market quality. The faster the temperature is reduced to the desired storage temperature, the longer is the storage life of the fresh produce. The objective of this study aims to investigate the effect of different hydrocooling time calculated at different fruit layer to storage quality of Saba banana fruit.

1.2 Justification

Postharvest loss of banana is one of the major problems faced by the banana producers as it is a climacteric fruit which degrades rapidly after harvesting. The total postharvest loss of banana was estimated to be 26.5%. A good temperature management, such as precooling and cold storage, can delay deterioration of fresh produce (Mebratie, *et al.*, 2015) because the temperature will influence the postharvest quality and longevity of fresh produce.

It is important to study on pre-cooling of the Saba banana because the market price of Saba banana nowadays is increasing and the export market demand is also increasing. This study also increases the potential to export Saba banana to the other country because currently this banana only being exported from Sabah to Peninsular Malaysia and Sarawak (Latip, 2015).

Application of precooling time effects on the physical and chemical quality of Saba banana (Supramaniam, 2016). Exposure time to low temperature influences the fruit quality specifically on the site of temperature monitoring. Supramaniam (2016), reported that the fruit layer at the core site of the fruit only was taken. Therefore, in this study, I monitored the temperature at different sites of the fruit was monitored. Obviously, the time taken to reach specific cooling time was different due to the site or thickness of fruit.

1.3 Research Objectives

The objectives of this study is to determine the effect of different pre-cooling time at different fruit layer and storage duration to the postharvest quality of Saba banana (*Musa balbisiana*)

1.4 Hypothesis

H_0: There is a significant effect of pre-cooling time at different fruit layer and storage duration to the postharvest quality of Saba banana (*Musa balbisiana*).

H_A: There is no significant effect of Pre-cooling time at different fruit layer and storage duration to the postharvest quality of Saba banana (*Musa balbisiana*).

CHAPTER 2

LITERATURE REVIEW

2.1 Banana

Banana is botanically known as *Musa* spp. It originated from South East Asian and western specific region where they are inedible, seed-bearing, deployed ancestors still can be found in natural forest vegetation (Constantine, 2001). Over many years, various inedible diploid of species of *Musa* crossed naturally resulted in the production of numerous intraspecific hybrid. Some of this hybrid produce edible fruit and it can be propagated vegetatively by suckers. In this manner, the superior edible crossed *Musa* would have been selected, cultivated, propagated and distribute locally as a food crop.

The banana fruit is categorised as a berry fruit. It varies in size, shape and colour. Generally, they are oblong, cylindrical, straight to strongly curved, which can vary from 3–40 cm long, and 2-8 cm in diameter. Banana plant can grow up to 9 m or 30 ft in height. The fruit skin is thin and tender to thick and leathery, turns from deep green to yellow or red, or, in some forms, green and white striped. The flesh colour can be ivory-white to yellow or salmon-yellow and the flavour range to starchy from sweet (TFN, 2006).

Banana is ranked at the fourth place as an important food crop in the world today after rice, wheat, and maize (INIBAP, 2000). *Musa* species have grown have varied human uses, ranging from the edible bananas and plantains of the tropics to ornamental plants that are used in landscaping. *Musa* plant is a source of food, beverages, fermentable sugars, medicines, flavourings, cooked foods, silage, fragrance, rope, cordage, garlands, shelter, clothing, smoking material, as well as numerous ceremonial and religious uses (Nelson, *et al.*, 2006). Basically, banana can fall into two sub-groups, namely *M. acuminata* AA and *M. balbasiana* BB (Stover, 1987). Hybridization between these two species gives rise to various diploid and tetraploid subspecies. The taxonomical hierarchy of banana is rather confusing and it does not conform fully to the Linnean system of plant classification. *Musa* species are usually group but according to their ploidy and the relative proportion of M. acuminata AA and M.Balbisiana BB in their genome. Most of the edible varieties are derived from triploid, although there are some being tetraploid (Robinson and Sauco, 2011).

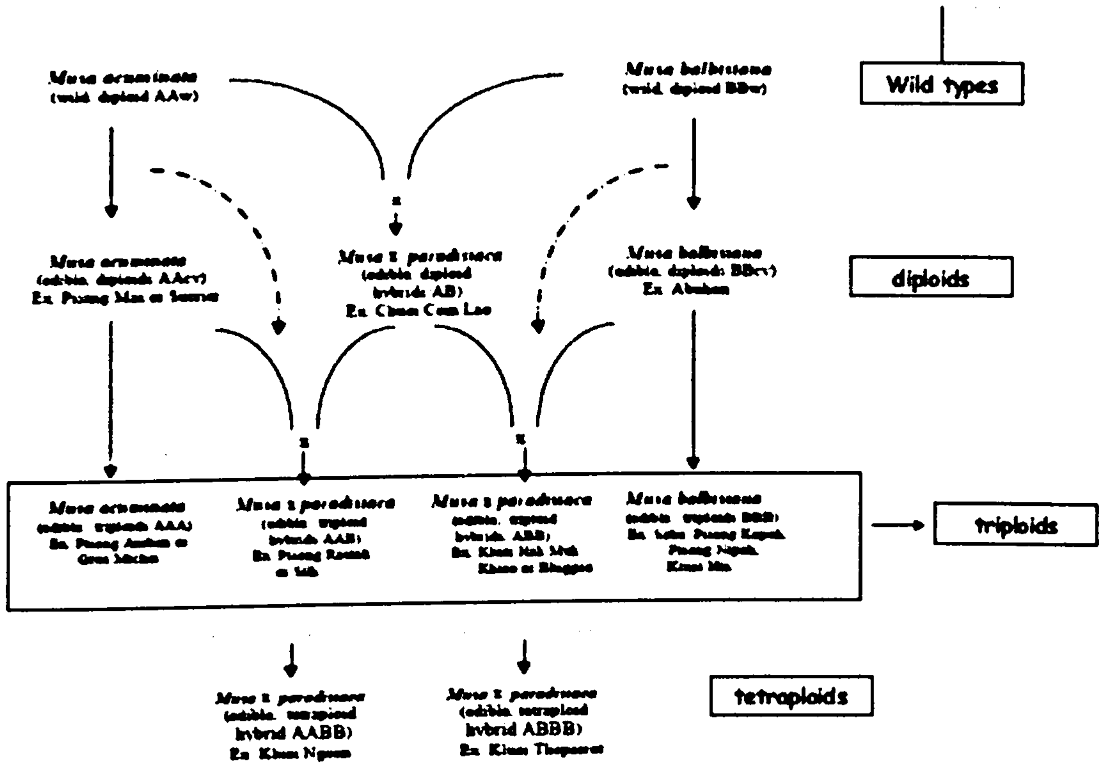

Figure 2.1 Various Pathways leading to the evolution of cultivated or edible banana

Source: (Deepthi, 2007)

Sweet or dessert banana is usually eaten raw at maturity belongs to the genomic group *acuminata* cultivars (AAA). Meanwhile, cooking banana are starchy types which are cooked before eating and constitute an important item in the diet of people in places where there is a shortage of staple food are categorically known as *balbisiana* cultivars (BBB) (Obiageli, *et al.*, 2016).

Saba banana is a triploid (BBB) banana cultivar originating from the Philippines. It is primarily a cooking banana though it can also be eaten raw. It is one of the most important banana varieties in Philippine cuisine. It is also sometimes known as the Cardaba banana, though the latter name may be more correctly applied to a very similar cultivar also classified within the Saba subgroup (HVDP, 2013). Saba bananas have very large, robust pseudostems that can reach heights of 20 to 30 ft (6.1 to 9.1

m) in height. The trunk can reach up 3 ft (0.91 m) in diameter. The trunk and leaves are dark blue- green in colour. Similar to other banana varieties, each pseudostem (trunk) flowers and bears fruits only once before dying. Each mat bears about eight suckers. In Malaysia, this type of banana also known as 'Pisang Nipah' (Ploetz, *et al.*, 2007)

2.2 Harvesting Recommendation

Banana harvesting is normally carried out in the morning and typically carried out by only one person, partly by cutting the pseudostem with a machete. Once harvested, the fruit is transported to processing or storage location. At the time of its sale, which usually occurs on the same day of its harvest, the bananas are cut from bunches into hands for transportation and arranged in boxes, basket or any packaging materials. Some farmers immerse the banana bunches into a container containing cold water or a 0.5% solution of water with some disinfecting products to sanitize the fruit in addition to coagulating and precipitating the sap so that the latex sap doesn't ooze out to spoil the appearance of the fruit (Kernaghan, 2014).

Export bananas are picked green and are usually ripened in special rooms upon arrival in the destination country. Fruit ripening is made in chambers with controlled temperature and humidity. To standardize the ripening period, and to increase banana shelf life, the fruit is acclimatized by the use of ethylene gas at a temperature around 16° C and at a relative humidity ranging from 85 to 95%. The shelf life is increased as all fruit is uniformly ripened at a lower temperature than under room conditions. The ethylene gas is a natural ripening hormone produced by many fruits such as bananas, apples, and pears. Even though the gas used for ripening commercial bananas is artificially produced, there is no evidence that the process is harmful to human health. In fact, the use of the gas is exclusively employed to bring uniformity to a natural process, thereby allowing and facilitating fruit commercialization. The average period from harvesting to a retailing destinations in either Europe or the United States varies between three and four weeks (Kernaghan, 2014).

2.3 Agronomic Issue and Challenges

The production technology of banana is simple and no fancy machine is needed. The farmers or workers immerse the banana bunches into large tanks of water so that the fruit is washed and goes through a grading process. Then the selected fruit is cut into smaller hands and directed to a second tank where they sit for approximately twenty minutes to allow the sap to coagulate and precipitate. After the hands are placed on a scale for weighing and all are sprayed with a natural fungicide, to prevent crown rot and to increase the shelf life of the fruit. All bunches are then packed and placed in boxes or any container then go export or market. In conventional practices, the fruit is ripened upon arriving in the destined country (Kernaghan, 2014).

Once the fruits are harvested, the overall quality of fresh fruits can hardly be improved. The final market value of the product depends on the grower's ability to apply best available pre-harvest technology followed by subsequent harvesting and then use of efficient post-harvest technology. The pre-harvest technology, like the use of fertilizers, pest control, growth regulators, climatic conditions like wet and windy weather and tree conditions, influence the fruit potentiality for storage by modifying physiology, chemical composition and morphology of fruits (Kernaghan, 2014).

2.4 Banana Grade and Fruit Layer

Grading is one of the most important procedures to be followed in postharvest handling, as it influence the quality, shelf life and price of the fruit. During grading, the produce is sorted according to the fixed grade standard, taking into consideration various quality factors to make a homogenous lot. Grading is mainly based on size, colour and maturity of the fruits. While grading, smaller fruits are separated from the larger ones in order to achieve uniform ripening. Immature, overripe, damaged and diseased fruits are discarded during the grading process (Agmark, 2000). The banana fruit are divided into three grade which is grade extra, grade 1 and grade 2.

Table 2.1 Standards for Grading of Bananas

Grade	Grade requirements	Grade tolerances
Extra class	Bananas shall be of superior quality. They must be characteristics of the variety and/or commercial type. The fingers must be free of defects, with the exception of very slight superficial defects, provided these do not affect the general appearance of the produce, quality, the keeping quality and presentation in the package.	5% of bananas (by count or by weight) not satisfying the requirements of the grade, but meeting those of Class grade or, exceptionally, coming within the tolerances of that class.
Class I	Bananas shall be of good quality. They must be characteristics of the variety and/or commercial type. The slight defects (as listed below) of the fingers, however, may be allowed, provided these do not affect the general appearance and quality of the produce in the package. - slight defects in shape and colour; - slight defects due to rubbing and other superficial defects not exceeding 2 sq.cm. of the total surface area The defects must not affect the flesh of the fruit.	10% of Bananas (by count or by weight) not satisfying the requirements of the grade but meeting those of Class II or, exceptionally, coming within the tolerances of that grade.
Class II	This includes bananas which do not qualify for inclusion in the higher classes but satisfy the minimum requirements. The following defects may be there provided the bananas retain their essential characteristics with respect to the quality and presentation. - defects in shape and colour provided the product remains the normal characteristics of bananas; - skin defects due to scrapping, scabs, rubbing, blemishes or other causes not exceeding 4 sq.cm. of the total surface area; The defects must not affect the flesh of the fruit.	10% of Bananas (by count or by weight) not satisfying the requirements of the grade, but meeting the minimum requirements.

Source: (Agmark, 2000)

For the fruit layer, the fruit temperature was taken at three different layer which is under the vascular tissue, mid-mesocarp and placenta (core).

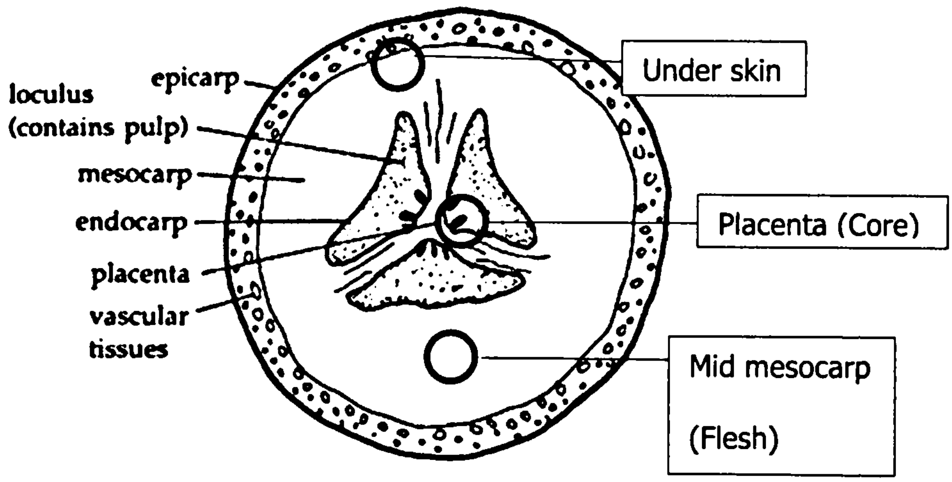

Figure 2.2 The biological Drawing of a Cross Section of a Banana.

Source: (Ahmad, 2007)

2.5 Effect of hydrocooling time to postharvest quality of Banana Fruit

2.5.1 Visual Appearance

Normally, the consumers mostly only looks at the physical appearance of the banana fruit before purchasing. Therefore, appearance makes consumers in making the decision to purchase the fresh produce. In reference to fruits and vegetables, the characteristics that impart distinctive quality may be described by four different attributes which are colour and appearance, flavour (taste and aroma), texture and nutritional value. Visual appearance is the first sensory attribute that can be evaluated by consumers (Valero and Serrano, 2010). In perspective of consumers, these four attributes typically affect in the order specified, for example, the consumer evaluate the visual appearance and colour first, followed by the taste, aroma, and texture. At the point of purchase, the consumer usually uses external appearance as an indication of freshness and quality of a fresh produce. Unattractive appearance of a fresh produce can eliminate the intended of a consumer to purchase that produce (Barette, 2010). The appearance of fruit generally characterized by uniformity of size, shape and colour. Colour and uniformity, glossiness and absence of defects in shape or peel and freedom from diseases are the essential components of visual quality (Valero and Serrano, 2010).

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