EFFECT OF HYDROCOOLING AND HOT WATER TREATMENT ON POST HARVEST PHYSIOLOGY OF SABA BANANA

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DECLARATION

I hereby declare that this dissertation is based on my original work except for citation and quotations which have been duly acknowledge. I also declare that no part of this dissertation has been previously or concurrently submitted for a degree at thesis or any other university.

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ABSTRACT

A study was conducted at Postharvest Laboratory in the Faculty of Sustainable Agriculture. The objective of this study is to determine the effect of hydrocooling and hot water treatment on post-harvest physiology of Saba banana. There were five treatments (control, hydrocooling, hydrocooling and hot water treatment, hydrocooling and hot water treatment and hydrocooling, and hot water treatment) tested in Saba banana which each treatment had three replicates. All the samples were stored at refrigerator (13±2°C), room temperature (26±2°C) and outside (30±2°C) in Faculty of Sustainable Agriculture for three weeks duration with seven days interval for data collection. The study found that there treated Saba banana showed significant differences in weight loss percentage (WLP) and total soluble solid (TSS). The total soluble solid showed the control treatment (11.84°Brix) was higher than treated banana. The Saba banana that stored in cold storage (13±2°C) showed a better storage condition for banana compared to room temperature (26±2°C) and outside temperature (30±2°C). The visual appearance score of the banana in cold storage was still acceptable (7.72) compared to the higher storage temperature in 3 weeks storage duration. The result showed that banana kept in cold have longer shelf life.
ABSTRAK

Satu kajian telah dijalankan di Makmal Teknology Lepas Tuai, Fakulti Pertanian Lestari, Universiti Malaysia Sabah. Tujuan kajian ini adalah untuk mangkaji kesan hydrocooling dan rawatan air panas pada fisiology lepas tuaian di atas pisang Saba. Terdapat lima rawatan (kawalan, hydrocooling, hydrocooling dan rawatan air panas, hydrocooling dan rawatan air panas dan hydrocooling, dan rawatan air panas) pada pisang Saba dengan tiga replikasi dan simpan in peti sejuk (13±2°C), suhu bilik(26±2°C) dan luar (30±2°C) in Fakulti Pertanian Lestari selama tiga minggu dengan tujuh hari selangan untuk pengumpulan data. Kajian ini menunjukkan pisang yang dirawat meningkatkan kehilangan berat. Manakala, kandungan pepejal larut (TSS) di pisang kawalan (11.84°Brix) lebih tinggi berbanding dengan lain. Di samping itu, pisang yang simpan di dalam keadaan sejuk (13±2°C) memberi jangka hayat yang panjang berbanding dengan suhu bilik (26±2°C) dan luar (30±2°C). Selain itu, pisang simpan di keadaan sejuk memberi markah penampilan visual (7.72) di dalam tiga minggu penyimpanan. Oleh itu, kajian menunjukkan pisang menyimpan di keadaan sejuk memberi jangka hayat yang panjang.
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CHAPTER 1

INTRODUCTION

1.1 Introduction

Banana is the world’s fourth most important food crop after rice, wheat and maize. More people in the tropic and sub-tropic region consume this fruit on a daily basis (FAO, 2008). The center origin of banana is Southeast Asia where Malaysia, Thailand, Philippines and Indonesia are the four countries that producers and exporters of the banana in the world. In particular, Malaysia is one of the banana exporter been gaining recognition since 1990 and in 2007 the exported banana reached almost 33840 tonnes (FAO, 2008). Saba banana is one of the banana type that grown in Sabah, Malaysia and almost can be found in the most of the market in the state. This banana is a major source of income for many planters in Sabah and food source to people. Saba banana also known as pisang kepok in Indonesia, pisang Nipah and pisang Saba in Malaysia (Valmayor et al., 2000).

Post-harvest losses of fruits are serious problem because of rapid deterioration during handling, transport and storage in tropical regions (Yahia, 1998). Once harvested, tropical fruit behave similarly to subtropical and temperate fruit. They transpire and wilt, respire and lose food reserves, many produce ethylene and ripen, senesce and become susceptible to microbial attack and finally die. Their ripening processes are also similar and include colour changes, usually from green to yellow or red (Siriphanich et al., 1994).

Temperature is one of the most important environmental factors that influence the deterioration of harvested fruits and hence its management during various postharvest operations like - pre-cooling, pre-treatments and storage plays a major role for extending the shelf-life (Hardenburg et al., 1986). Pre-cooling can immediately lower
the field heat of commodity following harvest and slow down metabolism and reduce deterioration prior to transport or storage (Nowak and Mynett, 1985 and Janick, 1986).

According to Nurul and Mosharraf (2012), heat treatment technology is relatively simple and non-chemical alternative that can kill quarantine pests (insect and fungi) of perishable commodities. Hot-water treatment also increases the shelf-life of banana and develop attractive colour. For this purpose this study is essential to minimize the problems of exportation and storage for marketing. The reduction in temperature has an added advantage in reducing the production and sensitivity of the produce to ethylene that accelerates ripening and senescence (Prange, 1994).

1.2 Justification of study

Nowadays fruits are consumed for their rich nutritive value and the growing global markets on transformation of tropical fruit such as banana into different product like juice. Postharvest losses of fruits are serious problem because of rapid deterioration during handling, transport and storage in tropical regions (Yahia, 1998). In Malaysia, banana is one of the important fruit crops cultivated in Malaysia. It is ranked second in terms of production area and fourth in export revenue based on the balance of trade figures. However, the shelf life of the banana is very short after harvest. Therefore, these banana should be preserves to extend its life span to avoid wastage potential of banana. Precooling and hot water treatment is the cheapest treatment using water temperature which may extend the shelf life of banana. Besides that, there were no similar research on Saba banana yet.

1.3 Objective

To determine the effect of hydrocooling and hot water treatment on post-harvest physiology of Saba banana.
1.4 Hypothesis

$H_0$: there is a signification different on the effect of hydrocooling and hot water treatment on post-harvest physiology of Saba banana.

$H_a$: there is no signficate different on effect of hydrocooling and hot water treatment on post-harvest physiology of Saba banana.
CHAPTER 2

LITERATURE REVIEW

2.1 Banana

Banana is an elongated fruit and a berry fruit. Flesh of the banana is yellowish-white, creamy, and sweet. When it is ripe its skin peels off easily. Its skin color varies from green, yellow or red depends on the variety (Morton, 1987). Banana and plantain is in Musaceae family, Musa species are indigenous to Southeast Asia and the Pacific (Simmonds and Shepherd, 1955). The word "banana" is a general term embracing a number of species or hybrids in the genus Musa of the family Musaceae (Morton, 1987). Banana is a climacteric fruit showing an increase in respiration resulting in colour, flavor, and aroma and texture changes. It is usually eaten raw when ripe and is a major starchy food common in Sub-Saharan Africa and Asia, providing quarter of carbohydrate (Adetunji et al., 2012). Banana plant belong to family Musaceae. There are two original species of banana which develop into different species nowadays. They are Musa acuminate and Musa balbisiana according to Stover and Simmonds in 1987. These two species interbred to form diploid, triploid and tetraploid subspecies which grouped based on the number of chromosome set they contain. The relative proportion of Musa acuminate (A) and Musa balbisiana (B) in their genome also been considered in grouping.

Principally, banana are divided based on eating type and cooking type banana. In Malaysia Bananas (Musa spp.) are amongst the most important food crops in the world. According to FAO in 2003, global banana production has been estimated to be about 99 million tons annually, mostly produced by tropical countries. Based on FAO (2003), banana is one of the important fruit crops cultivated in Malaysia. It is ranked second in terms of production area and fourth in export revenue based on the balance of trade figures. This crop will remain as an important industry, emphasis given to this crop in addition to the other fruit types listed under the National Agricultural Policy. In
Malaysia, banana is the second most widely cultivated fruit, covering about 26,000 ha (Siti, n.d.) with a total production of 530,000 metric tonnes with more than 15 % of the yearly production and a balance of trade of more than RM30 million (US$8 million). Based on Hussin and Robert (n.d), about half of the banana growing land is cultivated with Pisang Berangan and the Cavendish type. However, banana production in Malaysia has decreased because of an increasing threat of diseases (particularly Fusarium wilt), high labour costs and marketing issues. However, it is still popular grown and contributes about 16 % of the total fruit production areas. Banana remains the second most important fruit crop (after durian) in Malaysia, amounting to about 15% of the total acreage under fruits. In 2009, the total banana production value is estimated to be RM452.4 million (Hussin and Robert, n.d).

2.1.1 Type of banana

There are only a few large banana plantations in Malaysia. The popular dessert cultivars are Mas (AA), Pisang Lemak Manis (AA), Berangan (AAA), Rastali (AAB), Embun (AAA) and Cavendish (AAA); while the popular cooking cultivars are Nangka (AAB), Raja (AAB), Awak (ABB), Abu (ABB), Tanduk (ABB) and Relong (AAB) (Appendix A).

2.2 Saba banana

Saba banana is the name given in the Philippines to a cooking banana belonging to the Saba subgroup (Valmayor et al., 2000). According to Ploetz et al. (2007), Saba banana also called pisang Abu or pisang Nipah (Malaysia), pisang Kepok (Indonesia), ‘Kluai Hin’ (Thailand) and Cardaba (english). Saba banana have a scientific name of Musa acuminate x balbisiana (ABB group) ‘saba’ and synonyms included Musa x paradisiaca L. cultigroup Plantain cv. ‘Saba’. Saba banana is a triploid hybrid (ABB) banana cultivar originating from the Philippines. According to Jarret and Litz (1986), the Saba and Cardaba were earlier thought to have a BBB genomic composition however in the isozyme analysis indicate that both should be classified as ABB. This banana is primarily a cooking banana and also can be eaten raw. According to Wang and Kepler (2009), the Saba banana fruit shape straight, plump, strongly ridged longitudinally, highly angular, squashed together sideways, and average 6 inches long times 1.5 inches in diameter with blunt tips. The bunch is composed of straight and closely arranged fruits. The Saba
banana is produced in greatest amount in Philippines where around 1.5 tonnes annually (Valmayor, 1987).

2.3 Importance of banana

Bananas and plantain are one of the cheapest foods to produce and it cost of one kilogram banana production being less than other staple food such as rice, maize, potato and yam (Chandler, 1995). Banana (Musa spp.) with world production of 95.6 million tonnes per year (FAO, 2008) is a widely grown fruit crop in tropical and subtropical countries. In some countries, banana can be more than a food crop, they provide important source of fiber and use to ferment for alcohol production (Picq et al., 1998). According to Robinson (1996), banana can be consume when a low fat, low sodium and cholesterol free diet is required and particularly recommended for people who suffer cardiovascular and kidney problems, arthritis, gout or gastrointestinal ulcer. Due the fruit is convenient to carry, athletes consume as a quick and healthy method of replenishing energy because banana has high energy value (Encyclopedia of Foods and Culture, 2003). According to Lee (2008), banana contain high potassium which an average size of banana contain 450 to 467 mg potassium. In general, Lee (2008) stated that potassium is essential to keep human body pressure normal and also help in proper functioning of the heart.

2.4 Postharvest handling on fruit

After harvest, the quality cannot be improved but only maintained, hence, it is important to harvest fruits, vegetables, and flowers at the proper stage and size and at peak quality. According Hassan et al. (2015), the study of postharvest physiology is the science of study living plant tissue physiology after harvest. This has direct application to postharvest handling in establishing the storage and transport conditions to prolong the shelf life. As stated by Kader in 1992, estimated 5% -25% of fruits and vegetables leaving the farm is never been consume. Product that harvest in proper maturity last as long in storage compare to harvest immature or over mature (Wilson et al., 1995). Postharvest handling have many different type such as packaging, temperature control, sanitation, and ethylene. According to Hassan et al. (2015), postharvest temperature manipulation during distribution is an ongoing challenge for many products, particularly those being shipped by air or ocean container. Result of acceleration of climacteric
ripening and softening can be breaks in cool chain temperatures for an example on reduction in shelf potential for apples harvested and stored at the pre-climacteric stage of maturity (East et al. 2008).

2.5 Precooling

Field heat can cause rapid deterioration of some horticultural crops and therefore it is desirable to remove this heat as quickly as possible after harvesting. According to Hardenburg (1986), pre-cooling of fruits harvested in temperate regions was observed to be highly useful in extending the storage life and maintaining the qualities thereby getting better market price. Similarly, low temperature storage has been one of the most effective methods for maintaining the quality of most of the fruits and vegetables. Precooling is typically a separate operation from refrigerated storage and requires specially designed equipment (Fricke and Becker 2003). This method reduces the rate of respiration, ethylene production, ripening, senescence, undesirable metabolic changes and further decay (Hardenburg, 1986). There are many types of precooling method such as force air cooling, hydrocooling, vacuum and water spray vacuum cooling, room cooling and transport cooling (James and Thompson, 1998).

2.5.1 Hydrocooling

Hydrocooling is a common method of rapidly bringing fruits and vegetables to recommended storage temperatures (Thompson and Chen, 1989). According to James and Thompson (1998), hydrocooling uses water as the cooling medium and less widely used than forced air cooling. This method is not popular because some product cannot tolerate water contact and required water resistant packaging. Besides that, hydrocooling is effective and economical but there is some limitation because tends to produce physiological and pathological effects on certain product (Bennett et al., 1970). The removal of field heat, by pre-cooling the fruit, reduces postharvest decay, control development of physiological disorders; improve fruit quality and delay aging or ripening (Shehla and Tariq, 2007). Hydrocooling is fast because the cold water flowing around the fruit product causes the product surface temperature to basically equal that of the water (Ryall and Lipton 1979). The advantage of hydrocooling is causing no commodity moisture loss. According USDA (2004), in the point of view of consumer the quality of hydrocooled product is high and from producer standpoint with hydrocooled product the
weight is higher than non hydrocooled product which can bring higher income. There are some research on hydrocooling method according to DeEll (2000), cucumber surface colour are able to be improve with water temperature 10°C compared to non hydrocooled fruit after 10-12 days. Hydro-cooling lychee delayed pericarp browning and improved the overall quality of fruits after storage (Kesta and Leelawatana, 1992). Hydro cooling is achieved by dipping/ drenching, rinsing/ immersing or spraying cold water over the bananas bunches for effective field heat removal (Debabandya et al., 2010).

2.6 Hot water treatment

Nowadays, chemical treatments have been restricted as postharvest fungicide treatments of fruits in certain countries with this restriction the pesticide-free product demand increased drastically (Adaskaveg et al., 2002). Heat treatments such as hot water dips, vapour heat, or hot-air treatments have been shown to be effective as a non-chemical mean of improving postharvest quality of a range of horticultural products (Lurie, 1998). The Hot water treatment may affect ripening and protect against physiological disorders (Klein and Lurie 1992), and have been used as an effective alternative treatment for decay control (Cantwell and Nie, 1996). In the heat treatment type methods show that hot water immersion, humid vapour exposition and forced hot-air treatments are the main technologies of physical type used as pest and disease control in fruits and vegetables (Paull and Armstrong 1994).

2.7 Storage temperature

According to Chauhan et al., 2006, banana storage at low temperatures is a step in the cold chain, from the harvest to market, to extend the green-life of fruit. With this circumstance can substantially reduce the rate of many metabolic pathways that lead to fruit senescence, deterioration and decay of quality. Low temperatures temporarily impair ripening by maintaining the lowest possible ethylene concentrations but most tropical fruits undergo physiological disorders and deterioration of quality when exposed to low temperatures (Seymour et al., 1993 and Wills et al., 1989). With the research by Imahori et al., 2008, and Zamorano et al., 1994, a typical symptom of chilling injury and in the case of bananas is when the surface pitting at temperatures lower than 10 °C, though the pulp will not be exaggerated for several days, the skin may turn dark, which negatively affects the quality.
2.8 Maturity indices

'Maturity at harvest is an important factor affecting quality perception and the rate of change of the quality during postharvest handling’ stated book of Postharvest Handling: A System Approach by Robert and Stanley (1992). According Shewfelt et al. (1987), an ideal maturity index can be measured non-destructively and is ‘different at instinct levels of maturity and does not change with the time of storage’. Maturity indices can be determine in estimation of the duration of development such as measurement of size, weight, or density and physical attributes such as colour, firmness, and moisture or solid content and other chemical attributes such as starch, sugar or acid content. The common criteria or indices used in the assessment of maturity or time to harvest included following:

1. The banana visual appearance of hanging bunch and particularly by the angularity of individual finger (Palmer, 1971)
2. Fruits are harvested when fingers of the first and on bunch showed signs of ripening or yellowing or when the finger tips turn black (Dadzie, 1994).
3. According to the Dadzie in 1994, most of the banana plantation, fruits destined for distant markets are harvested at a stage known as ‘three quarters full’ which is the finger are still in angular whereas for local markets banana harvested when finger are full or rounded.

Figure 2.1 Banana Colour Guide.
Source: Dole Fresh Fruit Company, 2004

Overall, the important of maturity indices according to Hassan et al. (2015), is to ensure sensory quality such as flavour, colour, aroma and texture and nutritional quality
and adequate postharvest shelf life. Besides that, maturity indices also help in facilitate the schedule of harvest and packaging operation and marketing.

2.9 Quality changes of banana during storage period.

According to Valero and Serrano (2008), as the ripening-senescence process set in, the produce quality deterioration and susceptibility of the storage products to decay caused by microbial spoilage and pathogen increase gradually. The fruit quality required will be subject to the final use and it is well recognized that postharvest quality is determined by pre-harvest factors and appropriate handling, processing, packaging, and retailing. During the postharvest chain (from harvesting to retailing) the concept of fruit quality is frequently used but different depend on the level of grower, producers, handlers, packers, distributors, retailers, markets, and consumers wanted. According to Shewfelt (1999), the produce characteristics determine the quality, but consumer’s acceptability is determined by is perception and satisfaction. There are many quality change related to coating on fruit during storage which included physio-chemical changes such as weight loss percentage, visual appearance, colour, decay percentage, firmness, pH, total soluble solid and titratable acidity.

2.9.1 Weight loss

According to Gomez (2004), pre-harvest conditions mainly affect fruit quality, chemical composition, texture, and postharvest moisture loss. There are two element that lead to fruit weight loss: (1) water can no longer be taken up from soil due to the interruption of plant natural life cycle, and (2) water transpiration, which is a physical process by water vapour can permeate the stomas and epidermis. Water also lost through lenticels, which are the gaps in the periderm formed to enable gas exchange for respiration (Valero and Serrano, 2008).

In addition, according to Valero and Serrano (2008) emphasized in their book “the rate of postharvest water loss is dependent primarily on the external vapour pressure deficit, although other factors will influence the situation”. Besides that, the specific structure of the cuticle and extent of suberization in the periderm seem to be more important than thickness in improving resistance to the movement of water vapour.
According to the Valero and Serrano (2008) book showed that fruits with thick peels such as citrus species and banana can lose a considerable amount of moisture from skin without compromising edible quality. Besides that, the appearance of the fruit will deteriorate steadily with increasing water loss. Based on Ben-Yehoshua (1987), other thin-skinned fruits are more susceptible to water loss. When fruit exhibit considerable weight loss, the quality of the product is then regarded as poor due to loss of turgidity, and consumers do not accept a fruit that is soft, dull, and wrinkled. According to Amin (2012), the weight losses of banana variety BARI Kola 1 and Sabri Kola at different temperature treatments increased gradually with the increase of exposure period. It was also observed that there was a strong linear relationship between weight loss and exposure times.

2.9.2 Visual appearance

In the Postharvest Biology and Technology for Preserving Fruit Quality book by Valero and Serrano (2008), appearance is the vital factor for consumer in deciding the purchase of fresh product. The display of fruit is categorized by uniformity of size, shape, and colour. Essential components of visual quality include colour and colour uniformity, glossiness, absents of defects in shape or peel, and freedom from disease. From these components, colour contributes more to the assessment of quality than others single appearance factors. According to the book Routine Post-harvest Screening of Banana/plantain Hybrids by Dadzie and Orchard in 1997 stated that there are no universally recognised objective criteria for determining when to harvest banana, cooking banana and plantain.

2.9.3 Colour

Colour always the first quality that consumer that evaluate on the fruit on buying. The fruit colour will determine the economic value on a fruit. According to Silip (2014), the fruit colour change are involve with the changes on carbohydrate to glucose inside the fruit. Besides that, the fruit peel colour also changes indicate the maturity of a fruit that can be consume. According to Stintzing and Carle (2004), during storage of fruits colour may altered through the action of light, temperature, oxygen, metal ions, and endogenous enzymes. Natural colour from fruit and vegetables always been part of human’s everyday diet and help human to identify food and evaluate. Therefore, colour
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