HARVEST AND POSTHARVEST PHYSICOCHEMICAL CHARACTERISTICS OF THREE SELECTED SABA BANANA (*Musa balbisiana* cv. Saba) ACCESSIONS IN SABAH

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DECLARATION

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ABSTRACT

The study was carried out in the Postharvest laboratory of Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, campus Sandakan from 15th July 2016 until 15th September, 2016 to evaluate the standard quality of harvest and postharvest physical and chemical characteristic of three selected Saba banana accessions collected from three different district of Sabah (which were Sandakan, Keningau and Kota Marudu). The experiment was conducted in a Completely Randomized Design (CRD) with four replications from the three accessions based on maturity indices for each individual analysis test (3 X 8 X 4). Fruit characteristics of Saba banana at harvest including mean weight of banana hand, number of fingers per hand, volume of finger, geometric mean diameter, sphericity, and aspect ratio were analysed by using One-Way Analysis of Variance (ANOVA). Postharvest physical and chemical characteristics changes of Saba banana which were changes in weight loss percentage (WLP), pulp to peel ratio (q/q), pulp firmness (kgF), visual appearances (VA), degree of browning (DOB), pulp and peel colour in terms of lightness (L*), chroma (C*) and hue angel (h°) value, total soluble solid (TSS), pH value, titratable acidity (TA), pulp and peel moisture content (MC), and rate of filtration (ROF) were subjected to two-way ANOVA at 5% level of significance. The study rejected Ho whereby the harvest and postharvest physical and chemical characteristics of three selected Saba banana accessions in Sabah have a significant differences. The result shown that postharvest characteristics at harvest of Saba banana from each accessions were significant differences except number of fingers per hand. Both the weight of banana per hand and volume of finger of Saba banana from Kota Marudu was the highest as compared to other accessions. The extracted data shows significant differences in physical and chemical characteristics on a daily basis with passage of maturity stage. The most useful and reliable maturity indices for banana fruits of Saba variety were firmness, peel colour and total soluble solid content. The investigation can be helpful to process industry since the selection of fruit with optimum value of respective physicochemical property can yield the product with good quality. The physicochemical characteristics evaluated in this study can be important postharvest quality criteria for the processing, screening and breeding of Saba banana. Similar studies on the influence of climate and farmer's cultural practice can be done for further ascertain the changes in postharvest physical and chemical characteristics of Saba banana in Sabah.



CIRI-CIRI FIZIKAL DAN KIMIA SEMASA TUAI DAN PENGENDALIAN LEPAS TUAI BAGI TIGA AKSESI PISANG SABA (Musa balbisiana cv. Saba) TERPILIH DI SABAH

ABSTRAK

Kajian ini telah dijalankan di Makmal Pengendalian Lepas Tuai, Fakulti Pertanian Lestari, Universiti Malaysia Sabah, Kampus Sandakan dari 15 JULAI 2016 sehingga 15 September 2016 untuk menilai standard kualiti ciri-ciri fizikal dan kimia semasa tuai dan pengendalian lepas tuai bagi tiga aksesi pisang Saba yang terpilih di tiga daerah yang berlainan di Sabah (iaitu Sandakan, Keningau dan Kota Marudu). Eksperimen ini dijalankan sebagai dua faktor uji kaji faktorial dalam Design Rawak Lengkap (CRD) dengan empat ulangan daripada tiga aksesi berdasarkan indeks kematangan bagi setiap analisis ujian individu (3 X 8 X 4). Ciri-ciri buah Saba pisang pada ketika menuai termasuk berat min pisang tangan, jumlah buah pisang pada sesikat pisang, jumlah jari, diameter geometri min, 'sphericity' dan nisbah aspek telah dianalisis dengan menggunakan 'Satuhala Analisis Varians' (ANOVA). Perubahan ciri-ciri fizikal dan kimia lepas tuai bagi pisang Saba iaitu perubahan dalam peratusan penurunan berat (WLP), nisbah antara buah dan kulit pisang (g / g), ketegasan buah (kgf), penampilan visual (VA), tahap pemerangan (DOB), pulpa dan warna kulit dari segi ringan (L *), kroma (C *) dan warna malaikat (h°) yang bernilai, jumlah larut pepejal (TSS), nilai pH, tertitrat keasidan (TA), kandungan kelembapan kulit dan buah (MC) , dan kadar penapisan (ROF) telah dianalisi dengan menggunakan ANOVA dua hala pada tahap 5% signifikasi. Kajian ini menolak Ho dimana ciri-ciri fizikal dan kimia semasa tuai dan pengendalian lepas tuai bagi pisang Saba mempunyai perbezaan yang ketara. Keputusan menunjukkan bahawa ciri-ciri lepas tuai pada masa menuai mempunyai signifikan kecuali jumlah buah pisang pada sesikat pisang. Data yang diterima menunjukkan perbezaan yang signifikan dalam ciri-ciri fizikal dan kimia pada setiap hari dengan peringkatan kematangan buah. Indeks kematangan yang paling berguna dan boleh dipercayai untuk buah pisang Saba adalah ketegasan buah, warna kulit dan jumlah kandungan pepejal larut. Kajian itu boleh membantu dalam proses industri kerana pemilihan fizikokimia buah-buahan yang bernilai optimum boleh menghasilkan produk yang berkualiti baik. Ciri-ciri fizikokimia yang dinilai dalam kajian ini boleh menjadi kriteria kualiti pengendalian lepas tuai untuk pemprosesan, pemeriksaan dan pembiakan pisang Saba. Kajian yang sama pada pengaruh iklim dan amalan petani boleh dilakukan untuk terus memastikan perubahan lepas tuai dalam ciriciri fizikal dan kimia pisang Saba di Sabah.



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LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

| ANOVA | Analysis of Variance |
|----------------|--|
| CO | Carbon Dioxide |
| C* | Chroma Unit |
| CRD | Completely Randomized Design |
| °C | Degree Celsius |
| | Degree Of Browning |
| °Brix | Degrees Brix |
| FSΔ | Faculty Of Sustainable Agriculture |
| FΔMΔ | Federal Agricultural Marketing Authority |
| 1 AUIA A | Gram |
| 9 hr | Hour |
| | Honestly Significant Different |
| h ^o | Hue Angle Of Colour |
| inch | Inches |
| INIRAP | International Network For Improvement of Banana and Plantain |
| koF | Kilogram Force |
| * | Lightness Of Colour |
| - | Litre |
| m | Meter |
| Ma | Milligram |
| mL | Millilitre |
| min | Minutes |
| MC | Moisture Content |
| NS | Not Significant |
| 02 | Oxygen |
| % | Percentage |
| ROF | Rate Of Filtration |
| MYR | Ringgit Malaysia |
| NaOH | Sodium Hydroxide |
| SAS | Statistical Analysis System |
| TA | Titratable Acidity |
| TSS | Total Soluble Solids |
| UMS | Universiti Malaysia Sabah |
| VA | Visual Appearance |
| WLP | Weight Loss Percentage |
| w/v | Weight Per Volume |



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| 3.7 | Percentage of titratable acidity = Titre (mL) x <u>Normality of NaOH (0.1N) x Volume made up x 64 g x 100</u> Sample volume (10mL) x Sample weight x 100 | 31 |
| 3.8 | Wet weight of sample (D) = B – A Weight of dry sample (E) = C – A Moisture content (%) = $\frac{D-E}{D} \times 100\%$ | 31 |
| 3.9 | Rate of filtration (ml/min) = $\frac{Amount of banana juice(ml)}{Time of filtration (min)}$ | 32 |



CHAPTER 1 INTRODUCTION

1.1 Background

Banana is classified as major tropical zone fruit. It is a climacteric fruit which can be harvested mature-green and ripened off plant. In Malaysia, banana is considered as an important sources of food especially in the rural areas in which it is often used to extend, supplement or substitute staple food after wheat, rice and corn due to its easily accessibility and affordable price (Stover and Simmonds, 1987). Besides, banana is of great socio-economic and nutritional significance which help to generate significant export revenue and employment to indigenous people. Generally, banana is consumed both as an energy yielding food and as dessert on a daily basis.

Saba banana which its scientific name is *Musa balbisiana* cv. Saba, is mainly cultivated at Sabah states of Malaysia with the largest orchard at Kota Belud of 673.5 hectares (Nurhafiza, 2014) and almost can be found in most of the market of the state. The area of cultivating Saba banana is expected to expand in the near future due to the continuous increase of local and foreign demand. This cultivar is consider very new and infamous in the country even though the neighbor country, Philippine had grown it as the main cultivar throwback of twenty years ago. The strength of Saba banana which is resistant to major diseases that infested by other banana cultivars in the country have make it emerge to become popular amongst the population in Peninsula Malaysia during this few years.

Saba banana is a cooking banana whereby it is cooked before been eaten (Dadzie and Orchard, 1997). It attain height of four meters as the largest and tallest stem amongst all banana cultivar. It is hardy and resistant to drought. In fact, people at Peninsula Malaysia have many other choices on varieties of banana including 'Pisang





Berangan', 'Pisang Abu', 'Pisang Rastali', 'Pisang Tanduk', "Pisang Nangka' and 'Pisang Cavendish' for their purchase decision (Malik *et al.* 2011).

Before 2009, Saba banana is uncompetitive and infamous in Peninsula due to high shipment costs and high market price from Sabah. The price of Saba banana increase dramatically throughout the supply chain from post-harvest handling to exportation until it reach the destined retailed market. For the past three years, export of Saba banana to peninsula and Sarawak shown an exponentially increase whereby 500 tonnes of bananas were exported to other states from 200 farmers of Sabah in Year 2014. Federal Agricultural Marketing Authority (FAMA) continue buy Saba bananas from Sabah for export throughout the country due to other banana crops varieties such as Pisang Abu, Pisang Mas at peninsula had been affected by wide spread leaf spot disease called black Sigatoka (*Mycosphaerella fijiensis*) (Swennen, 1990).

A small trial shipment went to southern Johor in Year 2009 to test the market, followed by another in Year 2010, according to Mr. Sebastian Chew, the director of FAMA in Sabah. 180 tonnes of the fruit costing MYR 85,000 (\$ 27,300) in ten containers have been sold to peninsular customers. This amount is continuously increase throughout the years particularly those in Johor state whose banana plantations were hit hard by a mysterious disease since Year 2008. Manufacturers there turn the bananas into chips and condiments.

According to Kaliwon (2015), an assistant director for permanent crops development in the agriculture department, reported that the bananas can be harvested in nine or thirteen months after planting. Farm price of Saba banana varies between MYR 0.50-0.80 per kg, and it is sell for about MYR 1.50-1.80 per kg in the Peninsula market.



1.2 Justification of Study

The post-harvest characteristics at harvest is essential in the screening of new banana. In this study, we are interest to know the postharvest quality changes of Saba banana in Sabah. Depending on the locality or country, most producers and consumers of banana, cooking banana and plantain usually prefer large size bunches with large or small size fingers and/or long or short fingers.

In addition, screening of new Musa hybrids for their fruit physicochemical characteristics at harvest may be important in the design of packaging for the fruit which would enhance efficient handling and transportation. Assessment of the post-harvest quality attributes (such as peel and pulp colour, pulp firmness, total soluble solids, moisture and dry matter content) are important in determining fruit maturation and it could also complement sensory evaluation studies. Screening of new banana, cooking banana and plantain hybrids for their post-harvest characteristics at harvest would provide the plant breeder useful information for future breeding work. It would also enable meaningful comparison of new Musa hybrids to existing cultivars.

Faculty of Sustainable Agriculture, Universiti Malaysia Sabah has been at the forefront of carry out research on Saba banana with superior agronomic potential. The harvest and post-harvest physical and chemical characteristics of three Saba banana accessions need to be demonstrated in a standard quality to meet the exportation demand to prevent rejection from the imported states.

Research was undertaken to screen and characterise the harvest and postharvest attribute of Saba banana by using high technology tools at the field as well as at the laboratory. This research was carried out in order to generate a standard quality of harvest and post-harvest characteristics chart which can be referred by farmer or agroentreprenuer in the cultivating process to sustain the production of Saba banana at the state.



1.3 Objectives

The objective of the study were:

- i. To establish the major harvest and post-harvest physicochemical characteristics of Saba banana from three selected accessions in Sabah into a standard quality chart which will provide useful information to assist breeders and researchers in the post-harvest selection of Saba banana.
- ii. To identify the differences of postharvest physicochemical characteristics between the harvested Saba bananas from the three accessions.

1.4 Hypothesis

- H_o: There were no significant differences between the harvest and postharvest physicochemical characteristic of three selected Saba banana accessions in Sabah.
- H_A : There were a significant differences between the harvest and postharvest physicochemical characteristic of three selected Saba banana accessions in Sabah.



CHAPTER 2

LITERATURE REVIEW

2.1 Bananas

All edible banana fruits are produced by plants belonged to the genus Musa which is one of the genera in the family Musaceae (others two are Ensete and Musella). Its name comes from the Arabic word 'banan' which means finger (Lim and Tee, 2010). According to Robinson (2011), the banana (English) has various names: bananier (French), pisang (Malay, Indonesian), kluai (Thailand), chuoi (Vietnam), xiang jiao (Chinese).

Bananas are a major staple as well as cash crop in developing countries and the most eaten fruit in Europe and Northern America. World production of around 99 million metric tons in 2014 with India as the world top producing country give an annual banana production of 27.7 million tons from an area of 0.847 million ha (Hassim, 2016). While China as the second producing country (12.08 million tons) and Philippines as the third higher producing country has produce 8.05 million tons in Year 2013. Ranking of Malaysia in the production of banana is No.38 with only 288, 677 tons (0.29 million tons). Worldwide, 400 million people depend on banana for food security and income generation (Hoe et al., 2015).

According to Cruz et al., (2008), the bananas are indigenous to the Southeast Asia, Australia tropics and the Indian subcontinent, developing in modern time secondary loci of genetic diversity in Africa, Latin America, and the Pacific. It is likely to have been first domesticated in Papua New Guinea. The biggest markets for banana are North America and Europe followed by Japan and Eastern Europe (Hailu et al., 2013). Although bananas are one of the most important commercial crops in the world, it is estimated that 87% of banana production is consumed locally (Langhe et al., 2009).



2.1.1 Botanical of Banana

Banana plant is a giant (2 - 9 m) perennial monocotyledonous that classed as an arborescent herb. It trunk is a false stem called pseudostem and consists of concentric layers of leaf sheaths rolled into a cylinder of 20 - 50 cm in diameter. The morphology of banana trees is shown in Figure 2.1. While the true stem is a large underground corm. According to Bathan et al. (2010), the ideal conditions for banana growing are soil is deep, friable, and rich in organic matter with complete nutrient and mineral elements, and has adequate moisture throughout the year; soil texture of 40 % clay, 75 % silt or 85 % loam; soil pH of 6.5, soil topography of flat to rolling lands up to 45 degrees gradient. Banana grows well in tropical climate with temperature range of 22 to 32°C at land elevation from sea level above 1,000 meters (Huber, 1983).

Bananas are ideally suited for agroforestry, for interplanting in diversified systems, and for plantation-style cultivation in full sun. It grow vigorous where rainfall is distributed evenly throughout the year. The plants are susceptible to stunt and damage due to prolonged drought. The lifespan of individual plants is about 1-1.5 years. However, the bananas will continually reproduce asexually by shooting suckers from a subterranean stem. The plants produce leaves, flowers and foliage throughout the year. Individual plant only produces inflorescence and fruit once (Gervacio et al., 2008).

The fruit is a berry although it develops from an inferior ovary. The exocarp is made up of the epidermis and the parenchyma layer, with the flesh being the mesocarp. The endocarp is composed of a thin lining next to the ovarian cavity. The axial placenta has numerous airspaces and ventral vascular bundles (Morton, 1987). Each node of the rachis has a double row of flowers, forming a cluster of fruit that is commercially called a 'hand', with the individual fruit called a 'finger'.

There are many different sizes and shapes of fruit, with plantains being usually very large compared to the dessert-type bananas or others. The same is true for external and pulp colour, which normally vary from cream to slight orange. The fruit is variable in size, colour and firmness, but is usually elongated and curved, with soft flesh rich in starch covered with a rind which may be green, yellow, red, purple, or brown when ripe. The fruits grow in clusters hanging from the top of the plant (Picq, et al., 1998).



Cultivated varieties are typically seedless. When seeds are present, they vary among species in shape and morphology. Seeds of *Musa balbisiana*, parent of many commercial edible banana varieties, are dark brown, ovoid, about 4 mm (0.2 in) long, with a conspicuous white, powdery Endosperm.



Key

- 1. Pseudostem
- 2. Sucker
- 3. Single flower (front petal removed)
- 4. Single flower (petal not removed)
- 5. Leave
- 6. Bunch of bananas
- 7. Rachis

Figure 2.1Morphology of BananaSource:FAO, 2012

- 8. Bract
- 9. Male bud/ male flower
- 10. Corm
- 11. Underground stem (rhizome)
- 12. Finger
- 13. Hand of banana
- 14. Cross section of finger





2.1.2 Economical Importance and Uses of Banana

Bananas have varied human uses, ranging from the edible bananas to cold-hardy fiber, and ornamental plants. They have been a staple of the human diet since the dawn of recorded history. The fruit is served as a dessert (banana) or cooked and eaten as a staple (plantain) either as the green, half ripe, or ripe fruit. (Nelson *et al.*, 2006).

The banana is of great nutritional value. It is a rich sources of carbohydrates (Prabha and Bhagyalakhmi, 2011). Besides, it is an excellent source of potassium which is suitable for athletes owing to its higher energy potential and also help to prevent muscle spasms. Bananas can be used to fight intestinal disorders like ulcers, to overcome constipation and gastritis (Kumar *et al.*, 2012). Banana is carotenoids-rich which scientifically proven for their synergistic effects and protective properties against various degenerative disorders including cancer, stroke, cardiovascular, Alzhemier's disease and Parkinson's disease (Abdel, 2009).

Musa species attained a position of central importance within Pacific societies: the plant is a source of food, beverages, fermentable sugars, medicines, flavorings, cooked foods, silage, fragrance, rope, cordage, garlands, shelter, clothing, smoking material, and numerous ceremonial and religious uses (Turner, 1997). Leaves of banana have a wide variety of useful applications, including as disposable umbrellas, food wrappers, plates and temporary raincoats. It is commonly used for wrapping foods as well as food decoration. Some *Musa* species and hybrids with colourful floral bracts and flowers are utilized in tropical flower arrangements (Langhe *et al*, 2009). In addition, leaves can be used to wrap root balls of seedlings before transplanting.

Leaf fibers are used to make string, thread, and rope. In New Guinea, the leaf and plant fibers also used to make thread and cloth. *Musa basjoo* (the Japanese fiber banana) and *M. textilis* are still used to make high-quality clothing and fabrics (Aurore *et al.*, 2009). Thin parings carefully cut from the outer pseudostem of these fiber bananas are shiny, strong strips of natural fibers suitable for hand or machine weaving. Silage is make from fruits and stems to feed livestock such as cattle. Banana peels is a very nutritious food for animals.

Banana sap has been used in many cultures as dye. Any banana sap will stain clothes indelibly black colour. In India, the sap is used as tannin and for tattooing in some Pacific islands (Sudheer and Indira, 2007). Varieties that have red or golden colour

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