UNIVERSITI PUTRA MALAYSIA

QUALITY CHARACTERISTICS OF GUAVA (PSIDIUMGUAJAVA L. EV. KAMPUCHEA) IN RESPONSE TO HYDROCOOLING TIME, STORAGE TEMPERATURE AND STORAGE DURATION

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FP 2003 23

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MASTER OF AGRICULTURAL SCIENCE
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By

JUPIKELY JAMES SILIP

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Agricultural Science

May 2003

Dedicated To

My Wife, Son, Daughters and Parents

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfillment of the requirement of the degree of Master of Agricultural Science

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May 2003

Chairman: Associate Professor Siti Hajar Ahmad, Ph.D.

Faculty : Agriculture

The effects of cooling time, storage temperature and storage duration on the guava cv. Kampuchea were determined. Freshly harvested mature-green guava were precooled at 1/8, 1/4 and 1/2 cooling time using a modified hydrocooler and stored at 5, 10 and 15 °C for 1, 2, 3, 4, 5 and 6 weeks. Sample zero cooling time (control treatment) was only washed with distilled water (26.0$\pm$1.0 °C) for about one minute before storage. Only fruits which are well-formed, uniformed-size (350$\pm$50 g) and free from blemishes were selected for the experiment. The experimental design carried out RCBD with a factorial arrangement of treatments (4 cooling times x 3 storage temperatures x 6 duration of storage) with three replications, and two fruits for each replication. The results indicated that cooling time only effected the browning but it did not significantly effect the visual appearance, skin colour, weight loss, soluble solids concentration, titratable acidity, pH level and vitamin C. Precooled fruit at 1/8 had a lower incidence of browning compared to non-precooled and precooled at 1/4 and 1/2. Significant cooling time x storage temperature interaction only affected water loss. Weight loss was lower when fruits were precooled compared to when they are non-precooled and stored at 15 °C. Treatment combination of storage temperature x storage duration were found to have significant effects on the visual appearance, skin colour, weight loss and soluble solids concentration. However, the treatment did not significantly effect browning, titratable acidity, pH level and vitamin C. Storage temperature of 10 °C showed beneficial effect in the decrease of the loss of visual appearance, delayed changes on the skin colour, gave the lowest weight loss, and the lowest changes of soluble solids concentration. Acceptable visual appearance of the fruit stored at 10 °C was up to 3.6 weeks compared to only 1.6 and 1.3 weeks for the fruit stored at 5 and 15 °C, respectively. The limit of acceptable L*, C* and h° changes in this study were 65.33$\pm$3.3, 43.0$\pm$0.5 and 113.83$\pm$2.5, respectively and this colour space values corresponded to pale green fruit. The permissible water loss of 6% which equilibrium to the limit of acceptable visual appearance in fruit stored at 10 °C was prolonged to 3.5 weeks compared to only 1.4 and 0.8 weeks in the fruit stored at 5 and 15 °C, respectively. Maximum accumulation of soluble solids concentration in fruit stored at 10 °C was found lowest at only 5.43% compared to 6.43% on both fruit stored at 5 and 15 °C. In addition, respective to the temperature treatments the fruit stored at 10 °C was found to have the lowest incident on browning compared to those stored at 5 °C while the fruit stored at 15 °C were ripening, developing senescence, shrivelling and freckles. Results of this research can be used by guava producers in deciding the time level for their precooling and temperature setting for their cold room.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains Pertanian

CIRI-CIRI KUALITI JAMBU BATU (*Psidium guajava* L. Cv. Kampuchea) HASIL GERAKBALAS KEPADA MASA PENDINGINAN HIDRO, SUHU SIMPANAN DAN JANGKA MASA SIMPANAN

Oleh

JUPIKELY JAMES SILIP

Mei 2003

Pengerusi: Professor Madya Siti Hajar Ahmad, Ph.D.

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Kajian telah dijalankan untuk mengukur kesan rawatan prapenyejukan air sejuk, suhu simpanan dan jangka masa penyimpanan terhadap buah jambu batu (*Psidium guajava* L.) kultivar Kampuchea. Buah jambu matang yang baru dituai diprasejuk selama 1/8, 1/4 dan 1/2 masa prapenyejukan dengan menggunakan alat penyejuk air sejuk yang direka khas kemudiannya disimpan ke bilik penyimpanan bersuhu 5, 10 dan 15 °C selama 1, 2, 3, 4, 5 dan 6 minggu. Rawatan kawalan hanya dibasuh dengan air paip selama lebih kurang seminit sebelum disimpan di bilik penyimpanan. Hanya buah yang sempurna, berat seragam (350±50 g) dan bebas dari kecederaan dipilih untuk kajian. Kajian ini dijalankan dengan menggunakan reka bentuk penuh rawak berblok dengan rawatan disusun secara faktorial (4 masa prapenyejukan x 3 jenis suhu penyimpanan x 6 jangkamasa penstoran) dengan 3 replikasi dan 2 buah bagi setiap replikasi. Keputusan kajian menunjukkan bahawa masa prapenyejukan hanya memberi kesan yang bererti kepada kejadian keperangan kulit buah tetapi tidak memberi kesan yang signifikan kepada kehilangan daya tarikan luar buah, warna kulit, kehilangan air, jumlah pepejal terlarut, asid tertitrat, kadar pH dan vitamin C. Buah yang diprasejuk kepada 1/8 didapati mempunyai kadar keperangan terendah berbanding dengan buah yang tidak diprasejuk dan diprasejuk kepada 1/4 dan 1/2. Masa prapenyejukkan x suhu penyimpanan hanya memberi kesan bererti terhadap kadar kehilangan air. Jumlah kehilangan air adalah rendah bagi buah yang diprasejuk berbanding dengan yang tidak diprasejuk dan disimpan di bilik sejuk bersuhu 15 °C. Rawatan yang signifikan oleh suhu penstoran x jangkamasa penstoran adalah nyata signifikan kepada kualiti tarikan luaran buah, warna kulit, kehilangan air dan jumlah pepejal terlarut. Walau bagaimanapun, rawatan tersebut tidak memberi kesan yang signifikan terhadap asid tertitrat, kadar pH dan vitamin C. Suhu penyimpanan 10 °C menunjukkan pengurangan kadar kehilangan daya tarikan luar buah sehingga 3.6 minggu berbanding hanya 1.6 and 1.3 minggu bagi buah yang disimpan dalam suhu simpanan 5 dan 15 °C, mengikut turutan masing-masing. Tahap minima perubahan L*, C* dan h° buah yang bersamaan dengan tahap minima tarikan luar yang boleh diterima adalah 65.33±3.3, 43.0±0.5 and 113.83±2.5, mengikut turutan masing-masing. Warna kulit buah dengan bacaan ini adalah hijau pucat. Jumlah kehilangan air dibawah 6% atau bersamaan dengan tahap minima daya tarikan boleh diterima bagi buah yang disimpan dalam suhu 10 °C dipanjangkan sehingga 3.5 minggu berbanding hanya 1.4 dan 0.8 minggu bagi buah yang disimpan dalam suhu 5 dan 15 °C, masing-masing. Penghasilan jumlah pepejal terlarut bagi buah yang disimpan dalam suhu 10 °C didapati serendah 5.43% berbanding 6.43% bagi buah yang disimpan sama ada 5 atau 15 °C. Jika diambil kira kesan suhu penstoran sahaja, buah disimpan dalam suhu 10 °C menunjukkan jumlah terendah kadar keperangan berbanding dengan buah yang disimpan dalam 5 °C, sementara itu buah yang disimpan dalam suhu 15 °C masak dengan cepat dan diikuti dengan penuaan,

menunjukkan pengecutan, bintik-bintik keperangan dan menunjukkan kejadian membusuk yang lebih cepat. Hasil penyelidikan ini berguna kepada pengeluar buah jambu khasnya untuk menentukan tempoh masa prapenyejukan untuk prapenyejukan dan suhu penstoran yang terbaik. Hasil penyelidikan ini juga menyediakan maklumat awal dan kaedah kepada para jurutera petisejuk yang berminat mencipta sistem prapenyejukan air sejuk.

ACKNOWLEDGEMENTS

Praise be to God for upon His permission, I am able to complete this thesis smoothly. Words are inadequate to express my gratitude to a number of persons for their kind and generous help during the years in the making of this study.

I am grateful to the chairman of my supervisory committee, Associate Professor Dr. Siti Hajar Ahmad, a Postharvest Physiologists, Department of Agriculture Technology, Faculty of Agriculture for her supervision, kind support and encouragement beyond supervisory duties and at heart for being so patient and understanding.

I am also deeply indebted to Associate Professor Dr. Russly Abdul Rahman, for his kindness as my co-supervisor. I appreciate his constructive criticisms and his professional eye for accuracy, detail, and choice of words.

The words of "Thank You" are very inadequate to express my gratitude to Dr. Wan Mohammad Hj. Wan Abdullah as a member of my supervisory committee for his critical comments and suggestions on what has been written regarding the engineering facts.

Completion of this research work owes much to my wife, for her continuous encouragement and my beloved son Cyde and my beloved daughters Cylistah and Cyleen who provided constant source of inspiration for me to complete this research.

I would like to thank the following people who have helped me during the course of this study:

My father, mother and all my brothers and sisters (Staff Sarjan Mr. Casmir, Mr. Romondus, Mr. Benjamin, Mrs. Christopher, Miss. Selvia and Miss. Antonia), who give me constant encouragement, love and always ready to lend a helping hand.

I am indebted to my father and mother-in-laws and their children Mdm. Minie, Mdm. Justina, Mdm. Alice and Mr. Alex for their kind consideration and all their valuable support and I am also indebted to them for their support towards me and my family while I'm completing my study.

I am also grateful to Dr. Anuar Abd. Rahim and Dr. Asiah Abd. Malek for their help in statistical analysis. There were times when we have to refer to numbers of SAS references.

My colleagues Miss Phebe Ding, Miss Ila, Miss Sheda, Mr. Riduan, Mr. Chong, Mr. Reqeeb and Mr. Francis and Miss Sheri whose help and camaraderie are very much appreciated.

I am also grateful to Mr. Asghar Ali for his kindness in reading my pre-draft thesis and for the hours spent in discussion with me. I appreciate his constructive criticisms.

I am happy to say "*Ribuan terima kasih*" to Mr. Yew Choir Aik (Owner of Fussa Enterprise Sdn. Bhd) for his hospitality to my family since 1999.

Finally, most profound thanks go to the Ministry of Science and Technology of the Malaysia government for sponsoring my research and also to the people of the Faculty of Agriculture, UPM for providing me with a good environment for my studies in their prestigious and reputed faculty.

Working on this study had been a journey of faith for me; for this experience, I thank God.

Jupikely James Silip

May 2003

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CHAPTER 1

INTRODUCTION

Guava is a nutritious fruit (CSPI, 2002) with a high content of vitamin C (10 to 979 $mg.100^{-1}$ g) (Yusof, 1985; Wilson, 1980; Rathore, 1976; Chaudhry and Farooqi, 1970, El-zorkani, 1968). Fresh guava is popular as a table fruit especially when it is eaten with sour plum powder (ITI, 2002). However, the world market for fresh guava is for an ingredient in blended juices. The world export value of guava is estimated at RM1,762 million with the Malaysian market shares being only 0.5% in the year 2002 (FAMA, 2002a). The top three competitive producing countries are Mexico, Philippines and Brazil, while Malaysia ranked eighteen. The market potential value for this commodity in Malaysia in the year 2002 was estimated to be RM165 million (FAMA, 2002a).

Bidor (in Perak), produces guava commercially in Malaysia since 1978. Since then, guava production increased each year (FAMA, 2002a) and today, there are about 1,736 hectares of land planted, producing some 73,310 t of fruits (Anon, 2001). A private entrepreneur, the Golden Hope Fruit Industries Pte. Ltd. represents a significant investment in this commodity (Unido-aaitpc.com, 2000). Currently, the company is the biggest producer of pink guava puree in Malaysia and has captured 15% of the world's pink guava puree market.

Guava has a great potential as an export because of global demand (NASS, 2001). However, guava is a climacteric fruit (Reyes and Paull, 1995; Brown and Wills, 1983; Akamine and Goo, 1979), with relatively short shelf life due to its rapid ripening process (Pantastico, 1975). Therefore, guava cannot be sent to distant markets under normal conditions. This problem was reported to be induced by field heat and high temperature in the storage room (Dincer and Akaryildiz, 1993; Hardenburg et al., 1986; Boyette et al., 1989).

Field heat is the fruit temperature measured in the field and found to be strongly associated with direct exposure to sunlight (Ferguson et al., 1999) and consists of 75% from the total heat in harvested fruit (Hardenburg et al., 1986). The intensity and length of exposure time to sunlight increased the total heat in harvested fruit especially in a tropical country like Malaysia where the day temperature is high (30 ± 2 °C). At high temperature, the respiration activity is increased leading to depletion of nutrient reserves, and therefore, fruit senescence is accelerated. For instance, at 0 °C the strawberry has a respiration of about 18 mg $CO_2.kg^{-1}.h^{-1}$ and at 27 °C the respiration rate is greatly increased, reaching to 211 mg $CO_2.kg^{-1}.h^{-1}$ (Hardenburg et al., 1986). The respiration rate is closely related to deterioration after harvest (Farragher et al., 1984). For example, Reid (1991) stated that because of their high rate of respiration and low tolerance to heat, cut flower deteriorates rapidly at field temperature. The low quality effect from this field heat was reported to increase the loss of marketability in strawberry from about 80 to 93% (Mitchell et al., 1974) and increased the loss of ascorbic acids, soluble solids concentration, fructose, glucose, sucrose, firmness and titratable acidity (Nunes et al., 1995b).

Quick cooling or precooling is well known by many researchers to remove the field heat from freshly harvested produce in order to slow down metabolism and reduce deterioration prior to transport or storage (Turk and Celik, 1994; Rudnucki et al., 1991; Rudnucki and Nowak, 1990; Brennan and Shewfelt, 1989; Nowak and Mynett, 1985; Halvey and Mayak, 1981). If there is a delay in cooling, loss of quality could be reduced by keeping the produce under shade (Rickard et al., 1978). However, studies on responses of guava to precooling are still scarce.

Generally, the principle technique of precooling includes room cooling, hydrocooling, forced air cooling, package icing, vacuum cooling and cryogenic cooling, with many variations and alteration within each technique. Hydrocooling is a form of precooling in which the product is sprayed with or immersed in an agitated bath of chilled water (Wills et al., 1998; Lambrinos et al., 1997). The refrigeration capacity needed for hydrocooling is much greater than that required for holding a product at a constant temperature. Therefore, effective hydrocooling is the ability on the system to maintain the lowest chilled water temperature (Becker and Fricker, 2002). However, the use of water at temperatures of less than the lowest storage temperature recommended had been found to induce chilling injury in some fruits (DeEll et al., 2000) and prolonged exposure to low temperature during precooling had been reported to have negative effects on fruit quality (Osman and Mustaffa, 1993). Therefore, specific cooling time is very important in order to get the benefit of precooling. Half cooling time is the time required to reduce the temperature difference between the commodities and the cooling medium to half (Stewart and Couey, 1963; Guillou, 1960; Stewart and

Lipton, 1960). Therefore, if the product temperature is 28 °C and the coolant temperature is 2 °C, the length of time required to reduce the product temperature to 14 °C is the half-cooling time.

However, specific recommendation of cooling time for guava is not available because it depends on the method of precooling, initial and final products temperature and the flow and temperature of medium used (Anon, 1999). The choice of cooling time depends on the temperature required which is closer to the storage or transport temperature (Guillou, 1959). After precooling the product to the desired temperature, the next step is to maintain the temperature (Jobling, 2002). Storage at about 8-10 °C seems to be the optimum storage potential for mature green guava (Kader, 2000; Pantastico, 1975; Singh and Mathur, 1954). However, other researchers recommend 5 °C as the optimum storage temperature for guava (Rohani and Lam, 1992; Wills et al., 1983).

Due to lack of information on the cooling period, storage temperature and storage duration for guava, therefore, the objective of this study was to determine the guava (*Psidium guajava* L. cv. Kampuchea) quality characteristics as affected by hydrocooling time, storage temperature, storage duration and any possible interactions between hydrocooling time x storage temperature x storage duration.

CHAPTER 2

LITERATURE REVIEW

2.1 Guava

Guava belongs to the Myrtaceae family and the genus *Psidium* consist of about 150 species and only *Psidium guajava* is of economical importance (Ruehle, 1948). Guava has been cultivated in Malaysia for a long time (Allen 1969) but has never received as much attention as it has now. In Malaysia, it is known vernacularly as "jambu batu", "jambu biji", "jambu burung", "jambu Portugal" and "keliabas". The first name is the most widely used and it described the stone-like hardness of the young and unripe fruit. The generic name is derived from the Greek word "psidion" while the species name is derived from Spanish word "guayabe" meaning guava tree (Lim and Khoo, 1990). Guava has been grown in the West Indies since 1526 and was introduced by the Spaniards into Philippines, where the names "guayabas' or "bayabas" became well established. The guava was introduced into Malaysia during exchange of stock materials between Malaya and India (Burkill, 1935). This was evidenced by the name "jambu Portugal" which was listed by Ward in 1836 in the list of Malacca fruit trees and the local appellation "jambu" a word derived from Java.

There were 31 varieties grown in Malaysia (Lim and Khoo, 1990). The most popular cultivars with seeds are Kampuchea (Vietnam, GU8), Klom Toon (GU9) and Klom Sali (GU10) while seedless varieties are Thailand Apple and Bangkok Apple. Guava cv. Kampuchea originated from Kampuchea/Vietnam and was imported in 1978