UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF A NON-DESTRUCTIVE TECHNIQUE FOR ASSESSING INTERNAL QUALITY OF SAPODILLA FRUIT

AB. AZIZ BIN IBRAHIM

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Thesis Submitted in Fulfilment of the Requirement for
the degree of Master of Science in the Faculty of Engineering
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DEDICATONS

There are no better individuals to dedicate this achievement than to my late father, Ibrahim bin Muhammad (may Allah have mercy on him) for instilling in me a sense of value in learning and pursuit of knowledge; my mother, Eishah, for her constant prayer and all the pain in bringing up; my wife Latifah, for her support and love; and my children, Azlan, Adi, Sufian, Azrul and Azri, whom I hope will develop the passion to learn and desire to explore the frontier of knowledge

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master Science

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Chairman: Associate Professor Mohd. Nordin Ibrahim, Ph.D.

Faculty: Engineering

Non-destructive techniques (NDT) by impact response using Kiwifirm device and colour communicator using Chromameter against intrusive method using Steven QTS 25-texture meter were used to evaluate the ripeness of sapodilla fruit var. Subang. Kiwifirm score correlated well with the Steven QTS 25-texture analyser, whereas colour communicator did not detect any significant changes during ripening of the fruit. Kiwifirm value of 2.7, which is equivalent to 1750 g hardness, gave an indication of suitable stage for the fruit to be consumed. The value below 1.5 indicated that the fruit was overriped. Non-destructive technique using Kiwifirm device is also able to predict the storage life and the internal quality of sapodilla. Sapodilla fruit with the Kiwifirm score of below 6.0 at harvest was more acceptable by the sensory panellist. Fruits with a score of 6.1 to 7.0 could be stored for a longer period; however, the quality was not so good compared to those fruits having Kiwifirm score of below 6.0 at harvest. Fruits having Kiwifirm score of below 4.5 ripened within 1-3 days after harvest, thus

were not suitable for storage. No significant difference was observed in the colour notation system (L*, a* and b*) with fruit ripeness.

Kiwifirm device was found to be useful in detecting the stage of maturity of sapodilla fruit, predicting the quality and also the period at which the sapodilla fruit ripens. The power line ($Y=0.02X^{3.6026}$), which was derived from the relationship of score resultant from the impact response of Kiwifirm device and days taken for the fruit to ripen, can be used as a chart to predict and separate the fruit according to the predicted storage duration. Thus the technique can be used to group the fruits into either storage-marketing and utilization purposes, or only suitable group for certain markets. This strategy can be used to promote sapodilla fruits for distant market or export purposes. Postharvest losses, which occurred during storage and transportation, can be minimized.

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

PEMBANGUNAN TEKNIK TANPA MUSNAH BAGI MENILAI KUALITI DALAMAN BUAH CIKU.

Oleh

AB. AZIZ BIN IBRAHIM

Oktober 2001

Pengerusi: **Profesor Madya Mohd. Nordin Ibrahim, Ph.D.**

Fakulti: **Kejuruteraan**

Teknik penilaian buah tanpa musnah oleh pantulan sentuhan menggunakan peranti Kiwifirm dan pendekatan warna menggunakan Chromameter berbanding dengan cara tusukan oleh penganalisa tekstur QTS 25 telah diuji untuk menilai tahap kemasakan buah ciku var. Subang. Skor dari peranti Kiwifirm berkaitrapat dengan skor dari penganalisa tekstur-Steven QTS 25 manakala skor dari chromameter tidak menunjukkan perbezaan yang ketara selama kemasakan buah ciku. Nilai Kiwifirm 2.7 yang bersamaan dengan 1750 g kekerasan, menunjukkan buah ciku tersebut sesuai untuk dimakan. Manakala nilai dibawah 1.5 menunjukkan buah telah ranum. Teknik penilaian buah tanpa rosak dengan peranti kiwifirm juga boleh meramal jangkamasa simpanan dan kualiti buah ciku. Nilai dari peranti kiwifirm keatas buah ciku kurang dari 6.0 ketika dituai adalah lebeh diterima oleh penilai rasa. Buah yang ditunjukkan oleh nilai kiwifirm 6.1-

7.0 boleh disimpan lebeh lama tetapi kualitinya kurang baik berbanding dengan buah yang nilai nya 6.0 kebawah. Buah yang nilai dari kiwifirm kurang dari 4.5 akan masak dalam julat masa 1-3 hari selepas dituai. Justeru itu ianya tidak sesuai untuk disimpan. Tiada perbezaan ketara diperhatikan dalam sistem penunjuk warna (L*, a* dan b*) dengan tahap kemasakan buah.

Peranti Kiwifirm didapati berguna untuk mengesan peringkat kematangan buah ciku, meramal kualitinya apabila masak dan jumlah hari untuk kemasakannya. Garis kuasa ($Y=0.02X^{3.6026}$) hasil daripada pantulan sentuhan peranti Kiwifirm dengan buah dapat dijadikan carta panduan untuk menjangka dan mengasingkan buah mengikut jangkaan tempoh simpanan. Jadi teknik dan alat ini sesuai untuk mengasingkan buah kepada pelbagai gunaan, iaitu samada untuk simpanan, pemasaran mau pun untuk kegunaan semasa. Buah dapat diagihkan ke pasaran yang sesuai berdasarkan tempoh yang diambil. Strategi ini dapat mempromosikan buah ciku ke pasaran yang lebih jauh atau diekspot. Kehilangan lepastuai yang banyak berlaku ketika penyimpanan dan penghantaran dapat diminimumkan.

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Last but not least, I would like to express my love and gratitude to my family, my wife, children who were very supportive and understanding throughout the course of my study. May God bless you all.

I certify that an Examination Committee met on 23rd October 2001 to conduct the final examination of Ab. Aziz Ibrahim on his Master of Science thesis entitled "Development of Non-destructive Technique for Assessing Internal Quality of Sapodilla Fruit" in accordance with Universiti Pertanian Malaysia (Higher Degree) act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1980. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirement for the degree of Master Science.

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Date: 10 JAN 2002

Declaration Form

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

AB. AZIZ BIN IBRAHIM

Date: October 2001

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INTRODUCTION

1.1 Background

Sapodilla, *Manilkara zapota* (L.) Royen *(Achras Zapota* L.) locally known as ciku, belongs to the family sapotaceae. Sapodilla, a native of tropical America is well spread throughout the tropics. There is great variation in the size and form of sapodilla trees (Plate 1). Under favourable conditions, a seedling tree may grow to a height of 17 - 25m but under sub-optimal conditions it may be no larger than a large shrub (Anon, 2000). The tree bears flowers all year round and flowering is more profuse after rain (Plate 2). The fruit is a fleshy berry with one or more seeds, rough-surfaced fruit, round or egg shaped. The diameter of the fruit is from 4 to 9 cm and it generally weighs 70 to 200g. The fruit has a brown skin colour throughout development stage.

Sapodilla is the source of chicle, the principle ingredient in chewing gum. The chicle is extracted from the trunk of the tree as white latex exudates. Today, sapodilla is more cultivated for its fruit. Sapodilla is grown on commercial basis in India, Philippines, Sri Langka, Malaysia, Mexico, Venezuela, Guatemala and some other Central American countries. In Southern Mexico and Central America, sapodilla fruit is considered to be one of the best of tropical fruit and it is gaining popularity as a specialty fruit in restaurants in North America. Sapodilla is also a potential crop for subtropical climates (Michaelbart, 1996).

Sapodilla production in Malaysia was around 15,480 metric tons in 1989, with a value of RM 21.7 million (Zahari, 1992). The common local varieties are Jantung, Batawi, Pasir and Subang. The fruit is becoming one of the popular fruits especially var. Subang, which have a smooth texture and less latex compared to other varieties. As such var. Subang has a great potential for export to overseas markets.

Sapodilla is delicious when fully ripe and is eaten as a desert fruit. The fruit is climacteric in nature and hence needs careful postharvest handling to minimise losses after harvest (Roy and Joshi, 1997). The maintenance or improvement of the postharvest quality and the postharvest life of fresh fruits and vegetables is becoming increasingly important, as consumer now demands for quality produce. This has been partly as a response to a free market situation where the supply of all types of fresh fruits and vegetables constantly exceeds demand (Thompson, 1998). To maintain or increase market share, therefore, there should be increasing emphasis on quality.

Harvestable maturity of sapodilla fruit is around 7-8 months from flowering, depending on cultivars and environmental conditions during fruit development (Abdullah and Tarmizi, 1992). Substantial losses are encountered each year due to environmental induced alterations in the maturation time.

Sapodilla fruits, which are sufficiently mature for harvest, might not be ready for utilization. For example, sapodilla fruits to be held in storage for considerable time are harvested prior to having developed sufficiently for immediate consumption. With proper handling, they will continue to develop after harvest, reaching an acceptable level of culinary perfection.

Plate 1: Sapodilla tree, great variation in the size and form.

Plate 2: Sapodilla fruit appears throughout the year

Plate 3: Fruit maturity may vary greatly even within a single cluster.

Normally sapodilla is harvested at commercial maturity, using proper tools to avoid injury (plate 3). The fruits are then allowed to ripen before it can be sold in the market within a short period. The harvest maturity of sapodilla has a significant role in the postharvest behaviour of the fruits. If harvesting is done at an appropriate degree of maturity, it ripens within 3-7 days at ambient temperature with excellent quality attributes, while fruits picked at immature stage ripen to give poor-quality produce. Overmature fruits are vulnerable to handling and have a short shelf life, due to rapid degradation metabolism (Selvaraj and Pal, 1984). The fruit is climacteric in nature and hence needs careful postharvest handling to minimise losses after harvest (Broughton and Wong, 1979; Roy and Joshi, 1997).

The safe storage period of mature sapodilla fruits depends upon respiration rate and storage environment. Low temperature storage can extend the shelf life of sapodilla fruits by reducing in the oxidative metabolism and ethylene production (Lakshminarayana, 1980). Latifah (1989) reported that sapodilla could be stored for 3 weeks at 10°C (RH 85-90%). Prolonged storage causes development of chilling injury, which was obviously seen two or three days after the fruits being transferred to ambient temperature. The chilling injury symptom shown was either the fruits became too soft or failed to ripen (Latifah, 1993).

In sapodilla, firmness indicates the stage of ripeness, especially at the edible stage. Flesh quality of sapodilla varies greatly and cannot be determined from the outside. Several physiological disorders severely reduce their quality, for example, blemishes or internal browning. Fruits need to be sampled out to check for the internal quality, which involves cutting of the fruits. So far, there is no visual method to predict the maturity stage and the quality of ripen sapodilla at the harvesting stage. The consumer needs to press the fruit with their fingers to determine the degree of fruit ripeness.

After harvesting quality of sapodilla fruit need to be maintained until the fruit is utilised. Infield packing of the fruits was done immediately after harvesting, before repacking them at the packinghouse. At the same time, the fruit was normally inspected for external faults, which may have developed during handling or storage. The fruit was squeezed lightly with the thumb to check for its firmness or ripeness. All these activities will degrade the fruit quality, especially squeezing the fruit, as this will causes damage to the fruit. Further more, during harvesting or removing from the storage room, thousands of fruits may be inspected. Assessing the ripeness of the fruit by visual method is almost impossible; furthermore this operation needs a lot of labour and is very tedious. A device that can separate fruits by maturity, either by colour or firmness or both criteria, would have the potential to provide objective firmness inspection. Thus there is a need to establish a non-destructive method to overcome the problem.

Various methods are available for quality detection and sorting according to external fruit properties such as size, shape, colour and external defects. Internal properties, such as stage of ripeness, taste, flavour, proper structure, and internal damage such as fruit rot, are customarily linked indirectly with the fruit's external properties, or measured directly through destructive tests.

The use of non-destructive inspection method serves as a better, faster and reliable alternative for evaluating the internal quality of fruits. A non-destructive test (NDT), which does not penetrate the skin or damage the underlying flesh of the fruit, would allow the testing of every fruit, and repeated testing of the same fruit. This will improve prediction of storage life, thus providing many advantages for researchers and the industry alike. Other advantage is, the samples taken from packed fruit need not be replaced by new fruit. This has major advantages for quality control inspection with current handling systems. There is no mess or problem of the disposal of sampled fruit, as the fruit can be repacked or returned to the packing line. Thus on-line assessment of every fruit is possible.

The NDT is based on the detection of various physical properties, which correlate well with certain quality factors such as density, firmness, vibrational characteristic, x-ray and gamma ray transmission, optical reflectance transmission, electrical properties and nuclear magnetic resonance.

Numerous studies have been done to determine the effectiveness of the non-destructive techniques on selected temperate fruits. Zachariah (1976) reported that a number of researchers have investigated the electrical properties of fruits and vegetables. Hopkirk et al. (1996) found that kiwifirm device, a firmness tester developed by Industrial Research Limited, New Zealand correlated well with the penetrometer for evaluating the maturity of kiwifruit. Abbot and Liljedahl (1994), Abbot et al. (1992), Affeldt and Abbot (1989) studied acoustic methods, and reported that resonant frequencies in apples were significantly influenced by changes in fruit maturity or ripeness, size and condition. The characteristic of sapodilla fruit is more towards the characteristic of kiwifruit; thus the use of kiwifirm device is more appropriate. Changes to the colour of fruit surface are also studied to relate with the harvest maturity.

1.2 Objective

The objectives of the study are:

1. To establish a non-destructive technique for assessing the ripeness of sapodilla.
2. To predict the storage life and the internal quality of ripen sapodilla by non-destructive technique.