

**PHYSICAL CHARACTERISTICS WOUND IN
YOUNG GINGER (*Zingiber officinale* Roscoe)
RIZHOME DURING POSTHARVEST
DANDLING**

**PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH**

TING HUONG

**PLANT TECHNOLOGY PROGRAMME
SCHOOL OF SCIENCE AND TECHNOLOGY
UNIVERSITI MALAYSIA SABAH**

2007

BORANG PENGESAHAN STATUS TESIS@

JUDUL: PHYSICAL CHARACTERISTICS WOUND IN YOUNG GINGER
(Zingiber officinale Roscoe) RHIZOME DURING POSTHARVEST HAND

Ijazah: Sarjana Muda dengan kepujian dalam sains (Teknologi
tumbuhan)

SESI PENGAJIAN: 04 (May) - 07 (April)

Saya TINEI HUONG

(HURUF BESAR)

mengaku membenarkan tesis (LPS/Sarjana/Doktor Falsafah)* ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.

4. **Sila tandakan (/)

PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

SULIT

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh

Tine Huong
(TANDATANGAN PENULIS)

[Signature]
(TANDATANGAN PUSTAKAWAN)

Alamat Tetap: 8E, Zonong 8,
Jalan ulu sungit

Mirah, 96000 sibu, SARAWAK

Nama Penyelia

Tarikh: 24/4/07

Tarikh: _____

CATATAN: * Potong yang tidak berkenaan.

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

@ Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (LPSM).



UMS
UNIVERSITI MALAYSIA SABAH

**PHYSICAL CHARACTERISTICS WOUND IN YOUNG GINGER (*Zingiber
officinale* Roscoe) RHIZOME DURING POSTHARVEST HANDLING**

TING HUONG

UNIVERSITI MALAYSIA SABAH

**DISERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE OF BACHEOR OF SCIENCE WITH
HONOURS IN PLANT TECHNOLOGY**

**PLANT TECHNOLOGY PROGRAMME
SCHOOL OF SCIENCE AND TECHNOLOGY
UNIVERSITI MALAYSIA SABAH**

2007



UMS
UNIVERSITI MALAYSIA SABAH

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged.

Mac 2007

PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

Ting Huong

TING HUONG

Date: 24/4/07

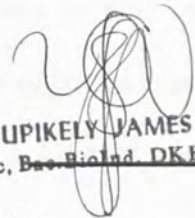


CHECKED BY

Signature

1. SUPERVISOR

(MR. JUPIKELY JAMES SILIP)


JUPIKELY JAMES SILIP
 Ms. Agri.Sc, Bsc. Biolnd, DKHP, Agri.Certif

2. EXAMINER 1

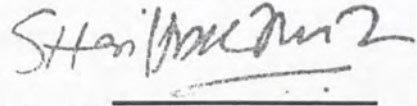
(MR. LUM MOK SAM)


LUM MOK SAM
 Pensyarah
 Sekolah Pertanian Lest
 Universiti Malaysia Sab

PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

3. DEAN

(SUPT/KS. PROF. MADYA DR. SHARIFF A.K. OMANG, ADK)





ACKNOWLEDGEMENTS

Praise is to God upon His permission, I could complete this thesis on time. As an appreciation, I would like to address my sincere gratitude to number of persons for their kind and patient to give a helping hand in my thesis. Without them, I would not have successes in doing my thesis.

I am grateful to my supervisor, Deputy Dean of School of Sustainable Agriculture, Mr. Jupikely James Silip for his support and advice when necessary.

I also want to thanks my parents, Mr Ting Ik Ding and Mrs. Lau Ai Hiong for providing the financial support to me to finish the thesis.

I am grateful to my housemate and course mate for giving some advised when necessary and encourage me to finish the thesis.

I would like to extend my ‘Thank you’ to the Pertubuhan Peladang Tambunan for sponsoring the samples to me to do the thesis.

Working on this study brings a lot of suffering to me but finally I managed to handle all the problems. This is the most experiencing job for me in Universiti Malaysia Sabah. For this I Thanks God.

ABSTRACT

This study had been done on the young ginger (*Zingiber officinal* Roscoe) rhizome to measure the effect of treatments and storage durations to the physical wound. The aim of this study was to reduce the physical wound in young ginger rhizomes during postharvest handling. By having the knowledge about the physical characteristics wound in young ginger rhizomes, the maximum level of damage could be reduced. Young ginger rhizome was harvested and treated with the abrasion, compression, abrasion and compression injuries. The young ginger rhizome without any injury treatment was used as the control. After being treated, the rhizomes were stored at room temperature for the periods of 0, 2, 4, 6, and 8 weeks. Completely random design was used in this study with a factorial arrangement of treatments by using 4 different of injuries (control, abrasion, compression, abrasion and compression) and the period of storage durations (0, 2, 4, 6 and 8 weeks). There were 5 replicates used per treatment in each experiment. The result showed that abrasion and compression would bring damage to the rhizome that will result in weight loss, increasing of firmness, defect on the visual appearance and changes on the parenchyma cell structure. Among the postharvest handling, abrasion and compression injuries stimulation gave the most defected visual appearance to the young ginger rhizome. The result showed that the highest weight loss (43.07%) was the rhizome treated with abrasion injury stimulation while the lowest weight loss (22.96%) was fresh rhizome (control). The result showed that, abrasion and compression injuries stimulation gave the most firmness to the young ginger rhizome with the increasing of storage durations. Besides that, the rhizome showed the increase of injury after storage. However, the destruction and ruptured only happened to the rhizome treated with abrasion, abrasion and compression injuries stimulation. In addition, the compress's rhizome and the fresh rhizome (control) did not show any destruction and rupture. This study showed that there were correlation between treatments and storage durations to the physical wound.

ABSTRACT

This study had been done on the young ginger (*Zingiber officinal* Roscoe) rhizome to measure the effect of treatments and storage durations to the physical wound. The aim of this study was to reduce the physical wound in young ginger rhizomes during postharvest handling. By having the knowledge about the physical characteristics wound in young ginger rhizomes, the maximum level of damage could be reduced. Young ginger rhizome was harvested and treated with the abrasion, compression, abrasion and compression injuries. The young ginger rhizome without any injury treatment was used as the control. After being treated, the rhizomes were stored at room temperature for the periods of 0, 2, 4, 6, and 8 weeks. Completely random design was used in this study with a factorial arrangement of treatments by using 4 different of injuries (control, abrasion, compression, abrasion and compression) and the period of storage durations (0, 2, 4, 6 and 8 weeks). There were 5 replicates used per treatment in each experiment. The result showed that abrasion and compression would bring damage to the rhizome that will result in weight loss, increasing of firmness, defect on the visual appearance and changes on the parenchyma cell structure. Among the postharvest handling, abrasion and compression injuries stimulation gave the most defected visual appearance to the young ginger rhizome. The result showed that the highest weight loss (43.07%) was the rhizome treated with abrasion injury stimulation while the lowest weight loss (22.96%) was fresh rhizome (control). The result showed that, abrasion and compression injuries stimulation gave the most firmness to the young ginger rhizome with the increasing of storage durations. Besides that, the rhizome showed the increase of injury after storage. However, the destruction and ruptured only happened to the rhizome treated with abrasion, abrasion and compression injuries stimulation. In addition, the compress's rhizome and the fresh rhizome (control) did not show any destruction and rupture. This study showed that there were correlation between treatments and storage durations to the physical wound.

ABSTRAK

Kajian telah dijalankan terhadap halia muda untuk mengukur kesan rawatan dan jangka masa penyimpanan ke atas kerosakan fizikal rizom halia muda (*Zingiber officinale* Roscoe). Kajian ini dijalankan untuk mengurangkan kerosakan pada halia muda semasa pengendalian lepas tuai dan menentukan ciri-ciri kerosakan fizikal pada halia muda supaya dengan pengetahuan terhadap ciri-ciri kerosakan maka kerosakan dapat dikurangkan. Rizom halia muda yang dituai dirawat dengan gosokkan, mampatkan, gosokkan dan mampatkan. Rizom halia muda kawalan tidak akan dirawat dengan sebarang rawatan. Selepas dirawat, maka rizom akan disimpan ke dalam bilik penyimpanan bersuhu bilik selama 0 minggu, 2 minggu, 4 minggu, 6 minggu, dan 8 minggu. Kajian ini dijalankan dengan menggunakan 4 jenis kerosakan (kawalam, gosokkan, mampatan dan gosokkan dengan mampatan) reka bentuk penuh rawak dengan rawatan disusun secara factorial dengan masa penyimpanan (0, 2, 4, 6, dan 8 minggu). Dalam eksperimen ini, setiap rawatan mempunyai 5 replikasi. Penyelidikan ini menunjukkan bahawa kesan rawatan gosokkan dan mampatkan akan membawa kerosakan seperti kehilangan berat, kekerasan, pertukaran dalam visual penglihatan, dan pertukaran dalam struktur parenchyma sel rizom halia. Daripada kesemua kendalian pasca tuai, stimulasi gosokkan dan mampatan memberi paling banyak kerosakan pada visual penglihatan. Keputusan menunjukkan kehilangan berat yang paling tinggi adalah rizom yang dirawat oleh stimulasi gosokkan (43.07%) manakala kehilangan berat yang paling sedikit adalah kawalan (22.96%). Selain itu, rizom menunjukkan kerosakan meningkat selepas penyimpanan. Walaubagaimanapun keruntuhan sel berlaku pada rizom yang dirawat oleh stimulasi gosokkan, dan stimulasi gosokkan dan mampatkan tetapi untuk rawatan yang lain, kesan mampatkan dan kawalan tidak akan meruntuhkan dinding sel. Kajian ini juga menunjukkan bahawa rawatan dan jangka masa penyimpanan mempunyai hubungan yang kuat dan rapat dalam mempengaruhi keputusan.

CONTENTS

	Page
DECLARATION	ii
CHECKED BY	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
ABSTRAK	vi
CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
UNITS	xiii
CHAPTER 1 INTRODUCTION	1
CHAPTER 2 LITERATURE REVIEW	
2.1 Ginger	6
2.2 Underground Vegetables Quality	8
2.2.1 Visual Appearance	9
2.2.2 Texture	11
2.2.3 Cell Structure and Plant Tissue	12
2.2.4 Nutrition Value	16
2.2.5 Mechanical Injury	16
CHAPTER 3 MATERIALS AND METHODS	
3.1 Location of Study	20
3.2 Material	
3.2.1 Young Ginger Rhizome	20



3.2.2	Penentrometer	21
3.2.3	Microtome	21
3.2.4	Light Microscope	21
3.2.5	Trinocular Microscope	21
3.3	Methods	
3.3.1	Harvesting	22
3.3.2	Handling	22
3.3.3	Cleaning	22
3.3.4	Drying	23
3.3.5	Packing and Grading	23
3.3.6	Transportation	23
3.4	Injury Stimulation	
3.4.1	Abrasion Injury Stimulation	23
3.4.2	Compression Injury Stimulation	24
3.4.3	Abrasion and Compression Injuries Stimulation	24
3.4.4	Storage and Packing	24
3.5	Physical Characteristic Analysis	
3.5.1	Weight Loss Determination	25
3.5.2	Visual Appearance Determination	25
3.5.3	Texture Determination	25
3.5.4	Cell Structure Characteristic	26
3.6	Experimental Design	26
3.7	Statistical Analysis	27



CAPTER 4	RESULTS	
4.1 Changes on the Visual Appearance		28
4.2 Weight Loss		33
4.3 Firmness		37
4.4 Changes on cell structure		40
CHAPTER 5	DISCUSSION	
5.1 Changes on visual appearance		46
5.2 Weight loss		48
5.3 Firmness		48
5.4 Changes of cell structure		49
CHAPTER 6	CONCLUSION	53
REFERENCES		55



LIST OF TABLES

Table		Page
2.1	Ginger chemical compositions.	16
3.1	The formula for calculating the firmness	26
4.1	Analysis of variance (ANOVA) between storage duration, postharvest Handling (treatment) and storage duration and postharvest handling to visual appearance of young ginger (<i>Zingiber officinale</i> Roscoe) rhizome.	30
4.2	Main and interaction effects of handling and storage duration (weeks) on visual appearance (scales), weight loss (%), and firmness (N) of young ginger rhizomes.	31
4.3	Analysis of variance (ANOVA) between storage duration, postharvest Handling (treatment) and storage duration and postharvest handling to the weight loss of young ginger (<i>Zingiber officinale</i> Roscoe) rhizome.	35
4.4	Analysis of variance (ANOVA) between storage duration, postharvest Handling (treatment) and storage duration and postharvest handling to the firmness of young ginger (<i>Zingiber officinale</i> Roscoe) rhizome.	38



LIST OF FIGURES

Figure	Page
2.1 The rhizome of ginger. 1. Mother rhizome. 2. Primary finger (first-order branch). 3. Secondary finger (second-order branch). 4. Tertiary finger (third-order branch)	8
2.2 Structure of plant cell	13
2.3 Structure of cell wall	13
4.1 Effect of postharvest handling and storage duration to the visual appearance scale of young (<i>Zingiber officinale</i> Roscoe) rhizomes. (---) indicate the limit of marketability according to its visual appearance.	32
4.2 Effect of postharvest handling and storage duration to the weight loss (%) of young (<i>Zingiber officinale</i> Roscoe) rhizomes.	36
4.3 Effect of postharvest handling and storage duration to the firmness (N) of young (<i>Zingiber officinale</i> Roscoe) rhizomes.	39
4.4 Cell structure of fresh young ginger rhizome (40 X using trinocular microscope)	42
4.5 Cell structure of young ginger rhizome ruptured (40 X using trinocular microscope)	42
4.6 The changes of parenchyma cell structure from 2 weeks to 8 weeks (40 X using trinocular microscope)	43
4.7 The parenchyma cell still looked like the intact cell in the control at 8 weeks.	44
4.8 The parenchyma cell wall of the young ginger rhizome was destroyed when treated by the abrasion injury stimulation at 4 weeks.	44



- 4.9 The parenchyma cell structure still looked like the intact cell but being compressed. 45
- 4.10 The total ruptured of the parenchyma cell walls of young ginger rhizome treated by the abrasion and compression injuries stimulation at 8 weeks. 45



UNITS

μm – Micrometer

kgf- Kilogram Force

F - Force

kg- Kilogram

cm- Centimeter

$^{\circ}\text{C}$ - Degree Celsius

m – Meter

gm - Gram

% - Percentage



CHAPTER 1

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) is a plant with an underground stem, or rhizome belonging to the family Zingiberaceae, which has been used as a medicine in Asian Arabic, and Indian herbal traditions since ancient times. Ginger is believed to be one of the first spices brought to Europe along the Silk Road from China. Arab merchants controlled the trade in ginger and other spices for centuries until explorers like Marco Polo reached the Indian Ocean. The Portuguese took ginger to their colonies and the Spaniards introduced it to the New World in 1547 they exported over 1,000 tons of rhizomes to Jamaica and Mexico, and by the end of the century had a thriving trade with Europe. Fresh ginger was cultivated throughout the tropics and is freely available (Paul-Urquhart and Jan, 1995).

Ginger grows in fertile, moist, tropical soil. Cold climate is also favorable to growth of ginger. The rhizome of the ginger plant is referred to as a root and is used as a spice in cooking and as a pickled vegetable. The knobby, fibrous mature root has a light yellowish brown skin when fresh (Robert and Ching, 1988). The creeping,



branched rhizomes grows near the surface, with pale yellow flesh beneath a thin, buff-colored to dark brown skin, look like knobby fingers and are often referred to as 'hands'. The stems can grow up to 120 cm tall, with narrow, lance-shaped leaves; the short-lived flowers are yellow-green and purple, marked with spots and stripes (Paul-Urquhart and Jan, 1995). High quality ginger is characterized by large thick rhizomes with limited branching white in color and glossy in appearance.

In China, for example, ginger has been used to aid digestion and treat stomach upset, diarrhea, and nausea for more than 2,000 years. Since ancient times, ginger has also been used to help treat arthritis, colic, diarrhea, and heart conditions. It is also help in recovering the common cold, flu-like symptoms, headaches, and even useful during painful menstruation periods. Ginger is most commonly known for its effectiveness as a digestive aid. By increasing the production of digestive fluids and saliva, Ginger helps relieve indigestion, gas pains, diarrhea and stomach cramping. In Malaysia, a decoction of the rhizome is taken for stomach-ache and as a tonic for women after childbirth. A lotion prepared from the rhizome together with vinegar is also used to rub over the body after childbirth as a protective medication. The rhizome is an effective treatment for flatulence, dyspepsia, colds, coughs, fever, nausea, vomiting, nosebleeds and rheumatism. A decoction of the rhizome and pepper is taken as an abortifacient. A decoction of the dried rhizome and coriander is a widely acclaimed remedy for colds and fever, while the juice mixed with garlic and bee's honey is a common remedy for coughs and asthma (Samy *et al.*, 2005). In addition to these medicinal uses, the value of ginger is increasing since it becomes a main cooking spice.



Nowadays, ginger is used throughout the world as a flavoring for sweet and savory dishes. It plays a starring role in foods like gingerbread, but also an integral part of many spice mixes, appearing in biscuits, cakes, soups, pickles, marinades, curry powder, stewed fruit, puddings, tea, beer ale, and wine. It was also the most important spice in Chinese cookery. In Japanese cookery it is used as a side dish called 'gari' to accompany sushi. Besides being used fresh, it is also used dried and in powdery form, ginger pickled, preserved in syrup, candied and crystallized. Rhizomes should be lightly scraped or peeled to remove the tough skin before use (Paul-Urquhart and Jan, 1995).

There are some mechanical stresses that may cause physical injury due to the improper handling during postharvest and storage. The mechanical stresses are secondary causes of loss which lead to conditions that encourage primary causes of loss and are usually a result of inadequate or non-existent handling equipment, technology and control (Peter *et al.*, 2002). Mechanical stresses cause physical injury or mechanical failure represents one of the most serious of quality loss during the postharvest period. Mechanical perturbations such as rubbing and wounding rapidly increase ethylene evolution. The volatile plant hormone ethylene is generated by plants under a variety of stressful conditions. Ethylene-induced ripening, senescence, flower fading, chlorophyll loss, abscission, physiological disorders, epinasty, and various tropistic and torsional responses contribute to the deterioration of horticulture commodities during transport and storage (Stanley, 1991). In some products, mechanical injury has been shown to be the primary cause of postharvest losses. The actual loss may be physical which mean loss of part of the product, physiological



caused loss in weight from increased water and respiratory losses, pathological which due to the facilitated entry of microorganisms, or qualitative (Stanley, 1991)). A rhizome having a level of moisture shrivels much faster than one having low moisture content under the same conditions. Therefore, handling and storage during post harvest is important.

Storage plays an important role in maintaining the high quality of the ginger rhizome. The extraction between the physical, chemical and biological factors within the ecosystem lead to changes in the quality and nutritive value of the stored product. The physical factors of most importance during storage are temperature, moisture content of the crop, relative humidity of the atmosphere and concentration of atmospheric gases such as oxygen and carbon dioxide. All living things within the store, including the stored product, insect, mites, and microorganism, are affecting each other and indeed interact within these factors. During all postharvest operations from fields to store, care is needed because their soft texture and high moisture content render them susceptible to mechanical injury. Physical factors can directly influence the quality of ginger. Changes in physical factors like ambient climate and deliberate manipulation can result in biochemical processes happening within the stored product, and this may prevent spoilage (Peter *et al.*, 2002).

Therefore, it is important to know the characteristics wound in young ginger rhizomes in order to have less sensitivity o the injury. It also can help in maintaining the high quality of the ginger crop in a proper way. For example, dropping fruit from a

height during harvesting can result in bruising which may only be apparent when the fruit starts to ripen. This is due to the careless handling (Peter *et al.*, 2002). Wound healing in developing apple fruit has been largely associated with wound periderm formation, which is lacking in fruit wounded after harvest. Wounds in mature “Golden delicious” and ‘Granny Smith’ apples became resistant to *Botrytis cinerea* and *Penicillium expansum* within 4 days at 5°C. The fruit tissue exhibited formation of wall thickenings extending 4 to 6 cell layers from the wound. Immediately after wounding, the wound cell walls were thin and collapsed. With time, the outer walls compacted together, and formed a dense fibrous layer which lined the wound surface. An examination of cell morphology showed that cells adjacent to the wound surfaces had no meristematic activity (Robert *et al.*, 1998).

Therefore, the objectives of this study are:

- I) To determine the physical characteristic wound in young ginger rhizome during postharvest handling.
- II) To determine the changes of cell structure of young ginger (*Zingiber officinale* Roscoe) rhizome during handling.

Hypothesis of this study are:

- I) Null hypothesis of this study is the mechanical injuries will cause the young ginger rhizome to damage during postharvest handling.
- II) Alternative hypothesis of this study is the mechanical injury will not cause the young ginger rhizome to damage during postharvest handling.

CHAPTER 2

LITERATURE REVIEW

2.1 Ginger

Ginger scientifically known as *Zingiber officinale* Roscoe is a monocotyledon which belongs to the family Zingiberaceae (Noor *et al.*, 2003). Compounds from rhizomes of *Z. officinale* are commonly called ginger, which has been purported to have anti-inflammatory actions. *Z. officinale* is a slender, erect, perennial herb that can grow to a height of 1 to 1.5 m. The plant has a pseudostem formed by the overlapping tubular leaf sheaths. The leaves are dark green, and narrow down evenly to a slender tip. The rhizome is about 2 cm thick, and it is brown externally and yellowish inside. The inflorescence arises directly from the rhizome and grows up to length of 15 to 20 cm (Samy *et al.*, 2005). The rhizome of the ginger plant is referred to as a root and was used as a spice in cooking and as a pickled vegetable.

According to Grieve (1992), ginger was naturalized in America after the discovery of that country by Spaniards. Francisco de Mendosa transplants it from the East India into Spain, where Spanish-Americans cultivated it vigorously. However, according to the Samy *et al.* (2005) ginger is native to India and China. It takes its name from the Sanskrit word *stringa-vera*, which means “with a body like a horn”, as



in antlers. Although it was grown locally in Malacca since 1416, *Z. officinale* is not native. Ginger has been important in Chinese medicine for many centuries, and is mentioned in the writings of Confucius. It is also named in the Koran, the sacred book of the Moslems, indicating it was known in Arab countries as far back as 650 A.D (Samy *et al.*, 2005).

There are at least 20 or more ginger species where have been cultivated for their use as spices, condiments, flavours, fresh vegetable, medicine, ornamentals and quite recently as cut flowers (Larsen *et al.*, 1999). In Malaysia, the young ginger's rhizome is sliced and eaten raw as 'ulam' or dipped in 'sambal' (Samy *et al.*, 2005). Ginger is an herbaceous perennial plant which is an important spice of South Asian origin. It is cultivated extensively in South-East Asia and Far East, and propagated vegetative through rhizomes. The ginger's rhizome looks like a knobby, fibrous mature root that had a light yellowish brown skin when fresh. The ginger's rhizome was also harvested at a very early stage before fiber development has been taken place, for used in pickles and confectionery (Robert and Ching, 1988). Ginger is a perennial, creeping plant, on thick tuberous rhizome, producing an erect annual stem 60–120 cm tall (Ravindran and Nirmal, 2005). Ginger is one of the most widely used spices and has been used in traditional oriental medicines for long time. Besides culinary use as a spice, *Zingiber* species are also used for their medicinal properties.

Ginger is marketed in 2 categories which are young ginger about 4 to 5 months and old ginger is about 9 to 10 months. The price is based on the grade which

differentiated into 2 grades, A and B. Grade A is clean, not injured, and fresh; with it weight more than 250gm. Its price is RM3.20 per kilogram in the field. Grade B is clean, not injured, and fresh, with it weight less than 250gm. Its price is RM2.00 per kilogram in the field (PPK Tambunan Sabah, 2006). However, the price of young ginger varies according to the locality, season, quality and type of ginger marketed (Jabatan Pertanian Sabah, 2006).



Figure 2.1 The rhizome of ginger. 1. Mother rhizome. 2. Primary finger (first-order branch). 3. Secondary finger (second-order branch). 4. Tertiary finger (third-order branch) (Ai *et al.*, 2005)

2.2 Underground Vegetables Quality

Quality is a term frequently used in postharvest studies, but rarely defined. Quality is defined as a series of attributes selected on the basis of accuracy and precision of measurement. These attributes are in turn used to evaluate the effect of a breeding line or transgenic product, chemical or quarantine treatment, handling technique or system, set of storage conditions or other postharvest variable on the fresh fruit or vegetable (Shewfelt, 1998). Quality of produce encompasses sensory properties such as

REFERENCES

- Abbott, A. 1999. Quality measurement of fruits and vegetables. *Postharvest Biology and Technology*: **15**, pp. 207-225
- Abbott, A. and Tianxia, W. 2001. Firmness and Force Relaxation Characteristic of Tomatoes Stored Intact or As Slices. *Journal of Postharvest Biology and Technology*: **24**, pp. 59-68.
- Aquino, S. D', Angioni, M., Schirru, S. and Agabbio, M. 2000. Quality and Physiology Changes of Film Packaged "Malvasio" Mandarins during Long term Storage. <http://www.idealibrary.com>.
- Ai, X.Z, Song, J.F. and Xu, X. 2005. *Ginger Product in Southeast Asia*. CRC Press. London.
- Clodoveo, J. Will, S. and John, J. S. 2006. *Fruit Quality*. Blackwell Science Ltd, UK.
- Edward, C. Lulai and Jeffrey, C. S. 2004. The involvement of ethylene in wound-induced suberization of potato tuber (*Solanum tuberosum* L.): a critical assessment. *Journal of Postharvest Biology and Technology*: **34**, pp. 105-112.
- Gloria, J. William, D. and Steve, C. 1995. Postharvest biology and handling of lonan fruit (*Dimocarpus longan* Lour.) *Postharvest Biology and Technology*: **26**, pp. 241-252.
- Gonzalez-Aguilar, G. A., Ruiz-Cruz, S. Cruz-Valenzuela, R, Rodriguez-Felix, A and Wang, C.Y. 2003. Physiological and quality changes of fresh-cut pineapple treated with antibrowning agents. *Journal of Food Science and Technology*: **37**, pp. 369-376.
- Grieve, M. F.R.H.S. 1992. *A Modern Herbal*. Jonathan Lape Ltd, London.



- Grosso, S. S. Peter, J. and Smith, V. 2004. *Postharvest Quality*. CRC Press. London.
- Jabatan Pertanian Sabah. 2006. *A Guide to Ginger Growing*. Bahagian Penerangan, Jabatan Pertanian, Ibu Pejabat, Kota Kinabalu, Sabah.
- Judith, B. David, M., Zakaria, F. Felix, E. and Beatrice, Conde-Petit. 2005. Structure-texture relationship of fresh pastes prepared from different yam (*Dioscorea* spp) varieties. *Journal of Food Science and technology*: **39**, pp. 762-769.
- Herold, B. Oberbarnscheidt, B. and Geyer, M.. 1998. Mechanical Load and its Effect on Bulb Onions due to Harvest and Post-harvest Handling. *Journal of Agriculture Engineering research*: **71**, pp. 373-383.
- Hong, G, Peiser, G. and Cantwell, M.I. 2000. Use of controlled atmospheres and heat treatment to maintain quality of intact and minimally processed green onions. *Journal of Postharvest Biology and Technology*: **20**, pp. 53-61.
- Krishna, K. and Sreenivasula, R. B. 2005. Post-harvest physico-mechanical properties of orange peel and fruit. *Journal of Food Engineering*: **73**, pp. 112-120.
- Kyung, H. C. Richard, A. L. and Karen, N. A. 1999. The 2.1 Structure of a Cysteine Ptrotease with Proline Specificity from Ginger Rhizome, *Zingiber officinale*. *Journal of Biochemistery*: **38**, pp. 11624-11633.
- Larsen, K, Ibrahim, H, Khaw, S.H, and Saw, L.G. 1999. *Gingers of Penisular Malaysia and Singapore*. Natural History Publications (Borneo), Kota Kinabalu.
- Li, Y., Brackett, R. E., Shewfelt, R.L. and Beuchat, L.R. 2001. Changes in appearance and natural microflora on iceberg lettuce treated in warm, chlorinated water and then stored at refrigeration temperature. *Journal Food Microbiology*: **18**, pp. 299-308.



- Malakou, C. 2005. *Postharvest of Fruit*. CRC Press, London
- Manjunatha, B.K. Krishna, V. Jagadeesh Singh, S.D, Vidyal, S.M., Mankani, K.L., Ramya Patavardhan, K.R, Shruthi P.R., and Sachin Bairy, L.. 2005. Wound Healing Potency of *Mucuna monosperma*. *Journal of Tropical Medicinal Plant*: **6**, pp. 7-13.
- Mencarelli, F., Massantini, R. and Botondi, R. 1996. Influence of impact surface and temperature on the ripening response of kiwifruit. *Journal of Postharvest Biology and Technology*: **8**, pp. 165-177.
- Mikal, E. 1999. Effect of ethylene on quality of fresh fruits and vegetables. *Journal Postharvest Biology and Technology*: **15**, pp. 279-292.
- Noor Azian, M. Mustafa, A.A. Kamal., and Nurul, M. A. 2003. Changes of cell structure in ginger during postharvest. *Journal of Food Engineering*: **62**, pp. 359-364.
- Noryati Ismail & Cheah Poh Bee (ptrj), 1998. *Lepas Tuai*. University Sains Malaysia, Pulau Pinang.
- Pantastico, ER. B (eds). 1995. *Fisiologi Lepas Tuai Pengendalian Dan Penggunaan Buah-buahan dan Sayur-sayuran Tropika dan Subtropika*. Dewan Bahasa dan Pustaka, Kuala Lumpur.
- Paul-Urquhart and Jan, P. 1995. *Ginger*. Kyodo Publication. Singapore.
- Peter, G. Graham, F. and John, E. O. (eds). 2002. Volume 1. *Crop Post-Harvest: Science and Technology*. Blackwell Science Ltd, UK.
- Peter, K.V, Nybe, E.V and Alice, K. 2005. *Yield Gaps and Constraints in Ginger*. CRC Press, London.
- PPK, Tambunan. Sabah. 2006. *Ginger*. Tambunan, Sabah.

- Ravindran, P.N. and Nirmal, B. K. (eds). 2005. *Ginger The Genus Zingiber*. CRC Press, London.
- Robert, A. S. Peter, G. S. Cheryl, L. L. David, S. and Louis, A. C.. 1998. Wounding, wound healing and staining of mature pear fruit. *Journal of Postharvest Biology and Technology*: **13**, pp. 27-36.
- Robert, E. P. and Ching C. C. 1988. *Ginger*. University of Hawaii Manoa, Honolulu, HI.
- Samy, J. Sugumaran, M. Kate, L.W.L. 2005. *Herb of Malaysia* (An introduction to the medicinal, culinary, aromatic and cosmetic use of herbs). Federal Publications Sdn Bhd. Malaysia.
- Shewfelt, R.L. 1999. What is quality? *Journal of Postharvest Biology and technology*: **15**, pp. 197-200
- Stanley, J. K. 1991. *Postharvest Physiology of Perishable Plant Products*. Van Nostrand Reinhold, New York.
- Thybo, B.M. and Sami, S. 2003. *Food Quality*. Blackwell Science Ltd, UK.
- Werner, B. H. Heike, M. and Martin, G. 1998. Effects of postharvest mechanical and climatic stress on carrot tissue water relations. *Journal of Postharvest Biology and Technology*: **16**, pp. 43-49.
- Wills, R.B.H., McGlasson, W.B., Graham, D., Lee, T.H and Hall, E.G. 1998. *Lepas Tuai Suatu Pengendalian Fisiologi dan Pengendalian Buah-buahan dan Sayur-sayuran*. Universiti Sains Malaysia, Pulau Pinang.

