# TABLE OF CONTENTS

## Page

TABLE OF CONTENTS	i
LIST OF TABLES	ii
LIST OF FIGURES	V
LIST OF ABBREVIATIONS	Х
INTRODUCTION	1
OBJECTIVES	3
LITERATURE REVIEW	4
MATERIALS AND METHODS	20
RESULTS	32
DISCUSSION	73
CONCLUSIONS	83
LITERATURE CITED	84
APPENDIX	102

i

## LIST OF TABLES

#### Table

1	Gene and sequences of primers used in RT-PCR analysis.	27
2	(A) Fatty acid composition (g /100 g fatty acid) in the peel of	
	cvs. Hom Thong and Namwa stored at 4 and 12°C.	44
	(B) Concentrations (g /100 g fatty acid) of unsaturated fatty acids	
	(UFA), saturated fatty acids (SFA) and their ratio in the peel of	
	cvs. Hom Thong and Namwa stored at 4 and 12°C.	45
3	(A) Fatty acid composition (g /100 g fatty acid) in banana peel.	
	Fruit of cvs. Hom Thong and Namwa were stored at 4 °C,	
	with or without prior immersion in hot water (42 °C for 15 min).	49
	(B) Concentrations (g /100 g fatty acid) of unsaturated fatty acids (UFA),	
	saturated fatty acids (SFA) and their ratio in banana peel	
	Fruit of the cvs. Hom Thong and Namwa were stored at 4°C,	
	with or without prior immersion in hot water (42°C for 15 min).	50
4	The size of amplified cDNA fragments and the sequences	
	of PPO, LOX, Hsp70 and 18S rRNA genes.	59

## Appendix Table

1 Chilling injury evaluation of banana peel cvs. Hom Thong and		
	Namwa stored at 4 and 12°C for 10 days.	105
2	Changes in peel color (L value) of banana cvs. Hom Thong and	
	Namwa stored at 4 and 12°C for 10 days.	106
3	Changes in electrolyte leakage of banana peel cvs. Hom Thong and	
	Namwa stored at 4 and 12°C for 10 days.	107

# LIST OF TABLES (Continued)

## Appendix Table

# Page

Changes in TBA-reactive compound of banana peel cvs. Hom Thon	
and Namwa stored at 4 and 12°C for 10 days.	108
Changes in total free phenolics of banana peel cvs. Hom Thong and	
Namwa stored at 4 and 12°C for 10 days.	109
Changes in LOX activity of banana peel cvs. Hom Thong and Namwa	
stored at 4 and 12°C for 10 days.	110
Changes in PPO activity of banana peel cvs. Hom Thong and Namwa	
stored at 4 and 12°C for 10 days.	111
Changes in POD activity of banana peel cvs. Hom Thong and Namwa	
stored at 4 and 12°C for 10 days.	112
Chilling injury evaluation of banana peel cvs. Hom Thong and	
Namwa stored at 4°C with hot water (HW) treatments at 42°C	
for 0, 5, 10 and 15 min.	113
Changes in peel color (L value) of banana cvs. Hom Thong	
and Namwa without (control) and with hot water (HW) treatment	
at 42°C for 15 min stored at 4°C.	114
Changes in electrolyte leakage of banana peel cvs. Hom Thong	
and Namwa without (control) and with hot water (HW) treatment	
at 42°C for 15 min stored at 4°C.	115
Changes in TBA-reactive compound of banana peel cvs. Hom Thong	
and Namwa without (control) and with hot water (HW) treatment	
at 42°C for 15 min stored at 4°C.	116
Changes in LOX activity of banana peel cvs. Hom Thong and	
Namwa without (control) and with hot water (HW) treatment	
at 42°C for 15 min stored at 4°C.	117
	Changes in TBA-reactive compound of banana peel cvs. Hom Thong and Namwa stored at 4 and 12°C for 10 days. Changes in total free phenolics of banana peel cvs. Hom Thong and Namwa stored at 4 and 12°C for 10 days. Changes in LOX activity of banana peel cvs. Hom Thong and Namwa stored at 4 and 12°C for 10 days. Changes in PPO activity of banana peel cvs. Hom Thong and Namwa stored at 4 and 12°C for 10 days. Changes in POD activity of banana peel cvs. Hom Thong and Namwa stored at 4 and 12°C for 10 days. Changes in POD activity of banana peel cvs. Hom Thong and Namwa stored at 4 and 12°C for 10 days. Chilling injury evaluation of banana peel cvs. Hom Thong and Namwa stored at 4°C with hot water (HW) treatments at 42°C for 0, 5, 10 and 15 min. Changes in peel color (L value) of banana cvs. Hom Thong and Namwa without (control) and with hot water (HW) treatment at 42°C for 15 min stored at 4°C. Changes in electrolyte leakage of banana peel cvs. Hom Thong and Namwa without (control) and with hot water (HW) treatment at 42°C for 15 min stored at 4°C. Changes in TBA-reactive compound of banana peel cvs. Hom Thong and Namwa without (control) and with hot water (HW) treatment at 42°C for 15 min stored at 4°C. Changes in LOX activity of banana peel cvs. Hom Thong and Namwa without (control) and with hot water (HW) treatment at 42°C for 15 min stored at 4°C.

#### LIST OF TABLES (Continued)

#### Appendix Table

14

15

16

at 42°C for 15 min stored at 4°C.

Changes in total free phenolics of banana peel cvs. Hom Thong	
and Namwa without (control) and with hot water (HW) treatment	
at 42°C for 15 min stored at 4°C.	118
Changes in PPO activity of banana peel cvs. Hom Thong	
and Namwa without (control) and with hot water (HW) treatment	
at 42°C for 15 min stored at 4°C.	119
Changes in POD activity of banana peel cvs. Hom Thong and	
Namwa without (control) and with hot water (HW) treatment	

iv

Page

120

# LIST OF FIGURES

Figure		Page
1	Mechanisms of phenolics oxidation leading to brown polymers	
	(Pourcel et al., 2006).	9
2	Enzymatic reactions for polyphenol oxidase and peroxidase	
	(Pourcel et al., 2006).	11
3	The different steps and the exponential amplification of the gene	
	in PCR (Vierstraete, 1999).	18
4	CI index in banana cvs. Hom Thong and Namwa.	21
5	Peel blackening in banana cvs. Hom Thong and Namwa stored	
	at 4 and 12°C for10 days.	35
6	CI evaluations in cvs. Hom Thong ( $\bullet$ ) and Namwa ( $\bigcirc$ )	
	stored at 12 (A) and 4 °C (B). Data are means $\pm$ SE of three	
	replications.	36
7	Changes in peel color (L value) of cvs. Hom Thong $(\bullet)$ and	
	Namwa ( $\bigcirc$ ) stored at 12 (A) and 4°C (B).	
	Data are means $\pm$ SE of three replications.	37
8	Changes in electrolyte leakage (%) of cvs. Hom Thong $(\bullet)$ and	
	Namwa ( $\bigcirc$ ) banana peel stored at 12 (A) and 4°C (B).	
	Data are means $\pm$ SE of three replications.	38
9	Changes in level of TBA-reactive compounds of cvs. Hom Thong	
	(•) and Namwa ( $\bigcirc$ ) banana peel stored at 12 (A) and 4°C (B).	
	Data are means $\pm$ SE of three replications.	39

	Page
Changes in total free phenolics of cvs. Hom Thong $(\bullet)$ and	
Namwa ( $\odot$ ) banana peel stored at 12 (A) and 4°C (B).	
Data are means $\pm$ SE of three replications.	40
Changes in LOX activities of cvs. Hom Thong $(\bullet)$ and	
Namwa ( $\bigcirc$ ) banana peel stored at 12 (A) and 4°C (B).	
Data are means $\pm$ SE of three replications.	41
Changes in PPO activities of cvs. Hom Thong $(\bullet)$ and	
Namwa ( $\bigcirc$ ) banana peel stored at 12 (A) and 4°C (B).	
Data are means $\pm$ SE of three replications.	42
Changes in POD activities of cvs. Hom Thong $(\bullet)$ and	
Namwa ( $\bigcirc$ ) banana peel stored at 12 (A) and 4°C (B).	
Data are means $\pm$ SE of three replications.	43
Peel blackening in cvs. Hom Thong and Namwa with and without	
HW stored at 4°C for 10 days.	51
CI evaluation in cvs. Hom Thong (A) and Namwa (B)	
stored at 4°C without ( $\bullet$ ) and with HW at 42°C for 5 ( $\blacksquare$ ), 10 ( $\blacklozenge$ )	
and 15 ( $\blacktriangle$ ) min. Data are means ± SE of three replications.	52
Changes in peel color (L value) of cv. Hom Thong banana peel	
with ( $\bigcirc$ ) and without ( $\bullet$ ) HW at 42°C for 15 min and cv. Namwa	
banana peel with ( $\triangle$ ) and without ( $\blacktriangle$ ) HW stored at 4°C.	
Data are means $\pm$ SE of three replications.	53
	Changes in total free phenolics of cvs. Hom Thong ( $\bullet$ ) and Namwa ( $\odot$ ) banana peel stored at 12 (A) and 4°C (B). Data are means ± SE of three replications. Changes in LOX activities of cvs. Hom Thong ( $\bullet$ ) and Namwa ( $\odot$ ) banana peel stored at 12 (A) and 4°C (B). Data are means ± SE of three replications. Changes in PPO activities of cvs. Hom Thong ( $\bullet$ ) and Namwa ( $\odot$ ) banana peel stored at 12 (A) and 4°C (B). Data are means ± SE of three replications. Changes in PPO activities of cvs. Hom Thong ( $\bullet$ ) and Namwa ( $\odot$ ) banana peel stored at 12 (A) and 4°C (B). Data are means ± SE of three replications. Changes in POD activities of cvs. Hom Thong ( $\bullet$ ) and Namwa ( $\odot$ ) banana peel stored at 12 (A) and 4°C (B). Data are means ± SE of three replications. Peel blackening in cvs. Hom Thong and Namwa with and without HW stored at 4°C for 10 days. CI evaluation in cvs. Hom Thong (A) and Namwa (B) stored at 4°C without ( $\bullet$ ) and with HW at 42°C for 5 ( $\bullet$ ), 10 ( $\bullet$ ) and 15 ( $\blacktriangle$ ) min. Data are means ± SE of three replications. Changes in peel color (L value) of cv. Hom Thong banana peel with ( $\odot$ ) and without ( $\bigstar$ ) HW at 42°C for 15 min and cv. Namwa banana peel with ( $\bigtriangleup$ ) and without ( $\bigstar$ ) HW stored at 4°C.

Figure

## 17 Changes in electrolyte leakage (%) of cv. Hom Thong banana peel with $(\circ)$ and without $(\bullet)$ HW at 42°C for 15 min and cv. Namwa banana peel with ( $\triangle$ ) and without ( $\blacktriangle$ ) HW stored at 4°C. Data are means $\pm$ SE of three replications. 54 18 Changes in level of TBA-reactive compounds (A) and LOX activities (B) of cv. Hom Thong banana peel with $(\bigcirc)$ and without $(\bullet)$ HW at 42 °C for 15 min and cv. Namwa banana peel with ( $\triangle$ ) and without ( $\blacktriangle$ ) HW stored at 4 °C. 55 Data are means $\pm$ SE of three replications. 19 Changes in total phenolics of cv. Hom Thong banana peel with ( $\bigcirc$ ) and without ( $\bullet$ ) HW at 42°C for 15 min and cv. Namwa banana peel with ( $\triangle$ ) and without ( $\blacktriangle$ ) HW stored at 4°C. Data are means $\pm$ SE of three replications. 56 20 Changes in PPO activities of cv. Hom Thong banana peel with ( $\bigcirc$ ) and without ( $\bullet$ ) HW at 42°C for 15 min and cv. Namwa banana peel with ( $\Delta$ ) and without ( $\blacktriangle$ ) HW stored at 4°C. Data are means $\pm$ SE of three replications. 57

Page

#### Figure

Page

viii

21	Changes in POD activities of cv. Hom Thong banana peel with	
	( $\bigcirc$ ) and without ( $\bullet$ ) HW at 42°C for 15 min and cv. Namwa	
	banana peel with $(\Delta)$ and without $(\blacktriangle)$ HW stored at 4°C.	
	Data are means $\pm$ SE of three replications.	58
22	Alignment of partial deduced amino acid sequence of banana peel	
	PPO cDNA fragment with other plants, Ananas (AF261957), Pyrus	
	(BAB64530), Triticum (ABK62804) and Oryza (ABG23059).	60
23	Alignment of partial deduced amino acid sequence of banana peel	
	LOX cDNA fragment with other plants. Prunus (CAB94852). Pvrus	
	(ABN09736). Corvlus (CAD 10740) and Solanum (AAD09202).	61
24	Alignment of partial deduced amino acid sequence of banana peel	
	$H_{sn}70$ cDNA fragment with other plants. Zea (CAC16168). Oryza	
	(CAA47948) Solanum (CAA37971) and Pisum (CAA83548)	61
25	Semi-quantitative RT-PCR of <i>PPO</i> expression in the peel of	01
23	cy. How Thong stored at $4^{\circ}$ C with and without HW at $42^{\circ}$ C	
	for 15 min	62
26	for 15 mm.	03
20	Semi-quantitative RT-PCK of <i>LOA</i> expression in the peer of	
	ev. Hom Thong stored at $4^{\circ}$ C with and without H w at $42^{\circ}$ C	
	for 15 min.	64
27	Semi-quantitative RT-PCR of <i>Hsp70</i> expression in the peel of	
	cv. Hom Thong stored at 4°C with and without HW at 42°C	
	for 15 min.	65

Figure		Page
28	Semi-quantitative RT-PCR of PPO expression in the peel of	
	cv. Namwa stored at 4°C with and without HW at 42°C	
	for 15 min.	66
29	Semi-quantitative RT-PCR of LOX expression in the peel of	
	cv. Namwa stored at 4°C with and without HW at 42°C	
	for 15 min.	67
30	Semi-quantitative RT-PCR of Hsp70 expression in the peel of	
	cv. Namwa stored at 4°C with and without HW at 42°C	
	for 15 min.	68
31	Relative expression of PPO gene in cv. Hom Thong banana peel	
	(A) and cv. Namwa banana peel (B) stored at 4°C with $(\Box)$ and	
	without $(\blacksquare)$ HW for 10 days.	70
32	Relative expression of <i>LOX</i> gene in cv. Hom Thong banana peel	
	(A) and cv. Namwa banana peel (B) stored at $4^{\circ}$ C with ( $\Box$ ) and	
	without HW for 10 days.	71
33	Relative expression of <i>Hsp70</i> gene in cv. Hom Thong banana peel	
	(A) and cv. Namwa banana peel (B) stored at 4 °C with $(\Box)$ and	
	without $(\blacksquare)$ HW for 10 days.	72

ix

### LIST OF ABBREVIATIONS

CI	=	Chilling injury
СО	=	Catechol oxidase
Ct	=	Cycle threshold
CV	=	Cultivar
СТАВ	=	Hexadecyltrimethylammonium bromide
EDTA	=	Ethylenediaminetetraacetic acid
Hsp	=	Heat shock protein
HW	=	Hot water
LOX	=	Lipoxygenase
MDA	=	Malondialdehyde
POD	=	Peroxidase
PPO	=	Polyphenol oxidase
PVPP	=	Polyvinyl polypyrolidone
RT-PCR	=	Reverse transcriptase polymerase chain reaction
SFA	=	Saturated fatty acid
TBA	=	Thiobarbituric acid
UFA	=	Unsaturated fatty acid