CONTENTS

Page

Acknowledgments c

Abstract in Thai d

Abstract in English f

Content h

List of Tables k

List of Figures l

List of Abbreviations p

Statement of Originality in English r

Statement of Originality in Thai s

Chapter 1 Introduction 1

1.1 Introduction 1
1.2 Purposes of the Study 2
1.3 Education/application advantages 2
1.4 Location 2

Chapter 2 Literature Review 4

2.1 Introduction 4
2.2 Component, chemical composition, nutritive and medicinal value of orange fruit 5

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

2.3 Some main causes affect the postharvest quality of orange fruit 10
2.4 Postharvest Technology of orange fruit 13
2.5 Application of PLA, bees wax and carnauba wax coating on fruit in Vietnam and in the World 24

Chapter 3 Effect of mixed wax coating on shrinkage pattern of orange fruit cv. Canh 26

3.1 Introduction 26
3.2 Materials and methods 27
3.3 Results and discussions 30
3.4 Conclusions 38

Chapter 4 Effect of mixed wax coating on postharvest qualities and storage life of sweet orange fruit cv. Canh during storage 39

4.1 Introduction 39
4.2 Materials and methods 40
4.3 Results and discussions 42
4.4 Conclusions 61

Chapter 5 Effects of PLA soaking in combination with mixed wax coating on qualities and storage life of Vietnamese orange fruit cv. Canh at ambient temperature 64

5.1 Introduction 64
5.2 Materials and methods 66
5.3 Results and discussions 70
5.4 Conclusions 81

Chapter 6 Effects of PLA soaking in combination with wax coating on qualities and storage life of Vietnamese orange fruit cv. Canh at 5ºC 83

6.1 Introduction 83

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

6.2 Materials and methods 84
6.3 Results and discussions 87
6.4 Conclusions 99

Chapter 7 Conclusions 101

References 102

Appendix 116

Appendix A 116
Appendix B 118
Appendix C 119
Appendix D 120

Curriculum vitae 128

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

LIST OF TABLES

Page

Table 2.1 Water vapour, O_2 and CO_2 permeability of edible coating 15

Table 3.1 The distance of convex spots on the top, bottom of mixed wax coated (4, 6, 8 and 10%) of orange cv. Canh fruit stored at 22 ± 2°C, 80 ± 5%RH 34

Table 3.2 Effects of MW coating on thickness on the top, middle, bottom of orange cv. Canh 36

Table 4.1 Effect of mixed wax on sensory in orange cv. Canh at 22 ± 2°C, 80 ± 5%RH 50

Table 4.2 Effect of mixed wax on sensory in orange cv. Canh at 5 ± 1°C, 80 ± 5%RH 60

Table 5.1 Antifungal activity of phenyllatic acid and mixed wax against mycelial growth *Aspergillus* sp. and *Penicillium* sp. after 7d 72

Table 5.2 Effect of PLA applied with mixed wax on *Penicillium* sp. mold incidence in orange cv. Canh 74

Table 5.3 Effect of PLA combined with MW on sensory values in orange cv. Canh 79

Table 5.4 Effect of PLA combined with MW on total microorganisms and total aerobic bacteria in orange cv. Canh 80

Table 5.5 Effect of PLA combined with MW on shelf life of orange cv. Canh fruit at 22 ± 2°C, 80 ± 5%RH. 81

Table 6.1 Effect of PLA combined with MW on sensory of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 95

Table 6.2 Effect of PLA combined with MW on shelf-life of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 96

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

LIST OF FIGURES

Page

Figure 2.1 Some main genus Citrus 6

Figure 2.2 Leaf, flower, fruit, treeof orange cv. Canh 9

Figure 3.1 Scanning electron microscope JSM-5410LV (a) and E600-Nikon (b) 30

Figure 3.2 Effect of bees-carnauba wax (MW) coating on shrinkage pattern on the top of orange cv. Canh peel stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 31

Figure 3.3 Effect of bees-carnauba wax (MW) coating on shrinkage pattern on the mildle of orange cv. Canh peel stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 31

Figure 3.4 Effect of bees-carnauba wax (MW) coating on shrinkage pattern on the bottom of orange cv. Canh peel stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 32

Figure 3.5 Wrinkle of Orange cv. Canh by microscope (taken 20 times) (Nikon Japan) 33

Figure 3.6 Convex spots of control orange cv. Canh (before, after storage) by SEM (x15) 34

Figure 3.7 a Convex spots of 4%MW orange cv. Canh (before, after storage) by SEM (x15) 35

Figure 3.7 b Convex spots of 6%MW orange cv. Canh (before, after storage) by SEM (x15) 35

Figure 3.7 c Convex spots of 8%MW orange cv. Canh (before, after storage) by SEM (x15) 35

Figure 3.7 d Convex spots of 10%MW orange cv. Canh (before, after storage) by SEM (x15) 36

Figure 3.8 Cross-section image of surface skin coated by SEM: control (a) and 8%MW (b) 37

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

Figure 4.1 Effect of bees-carnauba wax (MW) coating on titrable acid of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 43
Figure 4.2 Effect of bees-carnauba wax (MW) coating on total sugars of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 44
Figure 4.3 Effect of bees-carnauba wax (MW) coating on vitamin C of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 44
Figure 4.4 Effect of bees-carnauba wax (MW) coating on TSS of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 45
Figure 4.5 Effect of bees-carnauba wax (MW) coating on ethanol of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 46
Figure 4.6 Effect of bees-carnauba wax (MW) coating on decay of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 47
Figure 4.7 Effect of bees-carnauba wax (MW) coating on weight loss of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH) 48
Figure 4.8 Effect of bees-carnauba wax (MW) coating on respiration of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 49
Figure 4.9 Effect of bees-carnauba wax (MW) coating on titrable acid of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 51
Figure 4.10 Effect of bees-carnauba wax (MW) coating on total sugars of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 52
Figure 4.11 Effect of bees-carnauba wax (MW) coating on vitamin C of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 53
Figure 4.12 Effect of bees-carnauba wax (MW) coating on TSS of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 54
Figure 4.13 Effect of bees-carnauba wax (MW) coating on ethanol of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 55
Figure 4.14 Effect of bees-carnauba wax (MW) coating on decay of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 57
Figure 4.15 Effect of bees-carnauba wax (MW) coating on weight loss of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 58
Figure 4.16 Effect of bees-carnauba wax (MW) coating on respiration of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 59

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

Figure 4.17 Effect of bees-carnauba wax (MW) coating on storage time of orange cv. Canh fruit stored at 5 ± 1°C 80 ± 5%RH 63

Figure 5.1 Blue mold and green mold of orange cv. Canh 65

Figure 5.2 Symptoms and signs of post-harvest rot of orange caused by *Aspergillus* sp. and *Penicillium* sp. 71

Figure 5.3 Inhibitory activity of PLA combined with 8% mixed wax against *Aspergillus* sp. and *Penicillium* sp. germination after 48h 73

Figure 5.4 Effect of PLA combined with MW 8% on titrable acid oforange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 75

Figure 5.5 Effect of PLA combined with MW 8 % on TSS of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 76

Figure 5.6 Effect of PLA combined with MW 8% on decay oforange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 77

Figure 5.7 Effect of PLA combined with MW 8% on weight loss of orange cv. Canh fruit stored at ambient temperature (22 ± 2°C), 80 ± 5%RH) 77

Figure 5.8 Effect of PLA combined with MW 8% on storage time 25 days of orange cv. Canh stored at ambient temperature (22 ± 2°C), 80 ± 5%RH 82

Figure 6.1 Effect of PLA combined with MW on titrable acid of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 87

Figure 6.2 Effect of PLA combined with MW on total sugars of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 88

Figure 6.3 Effect of PLA combined with MW on vitamin C of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 89

Figure 6.4 Effect of PLA combined with MW on TSS of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 90

Figure 6.5 Effect of PLA combined with MW on ethanol of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 91

Figure 6.6 Effect of PLA combined with MW on decay of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 93

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright © by Chiang Mai University
All rights reserved

Figure 6.7 Effect of PLA combined with MW on weight loss of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 94
Figure 6.8 Effect of PLA combined with MW on storage time (a-g) of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH 100

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

LIST OF ABBREVIATIONS

A.	*Aspergillus*
AOAC	Association of analytical communities
BC wax	Bees and carnauba wax
CA	Controlled atmosphere
CBZ	Carbendazim
CMC	Carboxymethyl cellulose
CW	Chitosan wax
d	days
Fig.	Figure
GSC	Gas solid chromatography
h	hour
HDPE	High density polyethylene
HPMC	Hydroxypropyl methylcellulos
HWT	Hot water treatment
IMZ	Imazalil
L.	*Lactobacillus*
LDPE	Low density polyethylene
MA	Modified atmosphere
MAP	Modified atmosphere packaged
MARD	Ministry of Agriculture and Rural Development of Vietnam
MEA	Malt extract agar
MIC	Minimum inhibiting concentration
MW	Mixed wax (Bees wax - carnauba wax)
P.	*Penicillium*
PE	Polyethylene
PDA	Potato dextrose agar
PLA	Phenyllactic acid
RH	Relative humidity

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

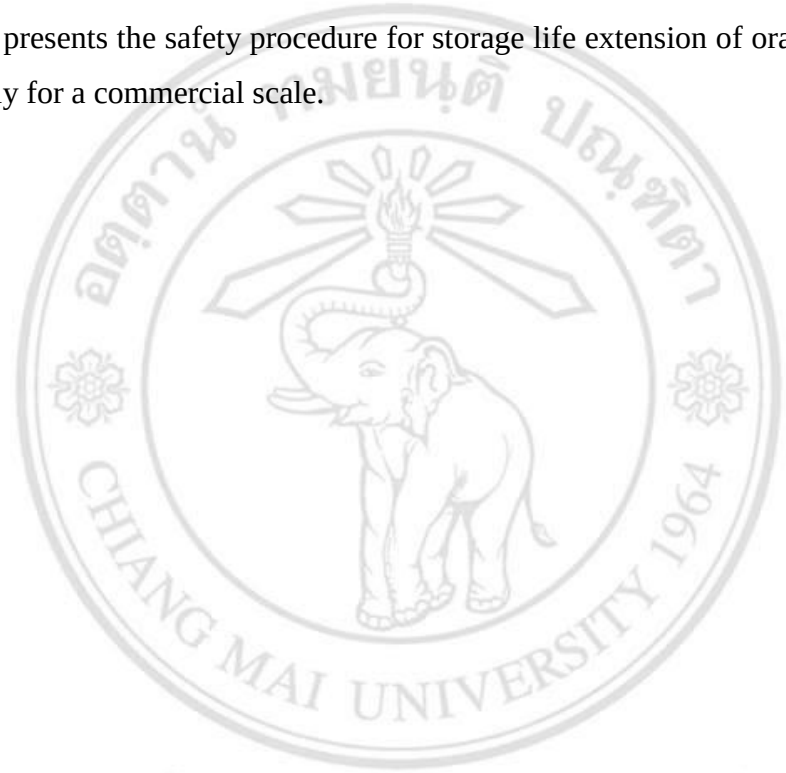
SEM	Scanning Electron Microscope
TA	Titrable acidity
Tab.	Table
TBZ	Thiabendazol
TSS	Total soluble solids
wk	week
Vit C	Vitamin C, Ascorbic acid

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

STATEMENT OF ORIGINALITY

1. I declare that this applied dissertation represents my original work, except where I have acknowledged the ideas, words, or materials of other authors by citing them in the required style.

2. This thesis presents the safety procedure for storage life extension of orange fruit and is able to apply for a commercial scale.



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

ข้อความแห่งการริเริ่ม

- ข้าพเจ้าขอยืนยันว่าวิทยานิพนธ์ที่นำเสนอนี้เป็นผลงานต้นฉบับของข้าพเจ้า ยกเว้นในส่วนของแนวความคิด ใจความ หรือข้อมูลที่ผู้ประพันธ์ท่านอื่น ๆ ซึ่งข้าพเจ้าได้นำมาอ้างอิง หรือ แสดงความขอบคุณไว้ในรูปแบบที่ต้องการ

- วิทยานิพนธ์นี้ได้นำเสนอแนวทางการยืดอายุการเก็บรักษาส้มเกลี้ยงที่ปลอดภัยและสามารถนำไปประยุกต์ใช้ในเชิงการค้าได้

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved