

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENT	ii
LIST OF TABLES	vi
LIST OF FIGURES	viii
LIST OF SCHEMES	x
LIST OF ABBREVIATIONS	xi
ABSTRACT	xiii
CHAPTER ONE: INTRODUCTION	
1.1 GENERAL INTRODUCTION	
1.1.1 Palm Oil Industry in Malaysia	1
1.1.2 Botany of the Oil Palm	2
1.1.3 Extraction of Palm Oil	4
1.1.4 Constituents of Crude Palm Oil	5
(a) Triacylglycerols	5
(b) Monoacylglycerols and Diacylglycerols	6
(c) Free Fatty Acids	7
(d) Carotenes	7
(e) Tocopherols and Tocotrienols	8
(f) Sterols	11
(g) Squalene	11
(h) Polar Lipids	11
1.2 PHOSPHOLIPIDS	
1.2.1 Introduction	12
1.2.2 Structure	13
1.2.3 Nomenclature	15
1.2.4 Biosynthesis	17
1.2.5 Properties of Phospholipids	19
1.2.6 Applications of Phospholipids	21
1.2.7 Recovery of Phospholipids	22

CHAPTER TWO: BIOCHEMICAL CHANGES IN THE DEVELOPING OIL PALM MESOCARP

2.1	INTRODUCTION	23
2.2	EXPERIMENTAL	
2.2.1	Materials	24
2.2.2	Extraction of Palm Mesocarp Oil	25
2.2.3	Purification of Palm Mesocarp Phospholipids	26
2.2.4	Determination of Total Phospholipids Content	27
2.2.5	Analysis of Phospholipids in Palm Mesocarp by 2D-TLC	27
2.2.6	Analysis of Phospholipids in Palm Mesocarp by HPLC-ELSD	28
2.2.7	Fatty Acid Composition Determination of Palm Mesocarp Phospholipids	29
2.2.8	HPLC Analysis of Tocopherols and Tocotrienols	30
2.2.9	HPLC Analysis of Carotenes	30
2.2.10	GC Analysis of Free Fatty Acids, Monoacylglycerols, Diacylglycerols, Triacylglycerols, Sterols and Squalene	31
2.3	RESULTS AND DISCUSSION	
2.3.1	Extraction of Palm Mesocarp Oil	32
2.3.2	Phospholipids	
(a)	Total Phospholipids Content	35
(b)	Analysis of Phospholipids in Palm Mesocarp by 2D-TLC	40
(c)	Analysis of Phospholipids in Palm Mesocarp by HPLC-ELSD	47
(d)	Fatty Acid Composition of Phospholipids	56
2.3.3	Sterols	58
2.3.4	Tocopherols and Tocotrienols	62
2.3.5	Carotenes	68
2.3.6	Diacylglycerols, Triacylglycerols, Monoacylglycerols and Free Fatty Acids	72
2.3.7	Squalene	77
2.3.8	Summary of Present Findings	78

CHAPTER THREE: RECOVERY OF PHOSPHOLIPIDS FROM PALM-PRESSED FIBRE

3.1.	INTRODUCTION	80
3.2	EXPERIMENTAL	
3.2.1	Materials	82
3.2.2	Stepwise and Direct Solvents Extraction	82
3.2.3	Open Column Chromatography using Octadecyl (C ₁₈)	83
3.2.4	Fatty Acid Composition Determination of Phospholipids in Palm-pressed Fibre	83
3.3	RESULTS AND DISCUSSION	
3.3.1	Stepwise and Direct Solvents Extraction	85
3.3.2	Purification of Phospholipids Using Octadecyl (C ₁₈) Open Column Chromatography	89
3.3.3	Synergistic Effect of Phospholipids	92
3.3.4	Summary of Present Findings	93
	REFERENCES	95
	APPENDIX 1	
	APPENDIX 2	
	APPENDIX 3	

LIST OF TABLES

Table		Page
1.1	Fatty Acid Composition (%) of Malaysian Palm Oil	6
1.2	Triacylglycerols in Crude Palm Oil	7
1.3	Carotenes Composition (%) of Crude Palm Oil	9
1.4	Vitamin E Composition (%) of Crude Palm Oil	10
1.5	Phospholipids Composition (%) of Palm Oil	14
2.1	HPLC Solvent System for Phospholipids Analysis	29
2.2	Extraction of Mesocarp Oil from Palm Fruits at Different Stages of Ripeness	33
2.3	R _f Values of Phospholipid Standards	41
2.4	Phospholipids at Different Stages of Development Palm Mesocarp	42
2.5	Phospholipids Composition in the Developing Palm Mesocarp	51
2.6	Fatty Acid Composition of Phospholipids in Palm Mesocarp	57
2.7	Concentration of Vitamin E Isomers in the Developing Palm Mesocarp	64
3.1	Phospholipid Content from Palm Oil Milling	81

Table		Page
3.2	Solvent Systems for Octadecyl Open Column Chromatography	84
3.3	Stepwise Solvents Extraction of Phospholipids	86
3.4	Direct Solvent Extraction of Phospholipids	86
3.5	Phospholipids Composition of Palm-pressed Fibre Oil	87
3.6	Fatty Acid Composition of Phospholipids in Palm-pressed Fibre Oil	89
3.7	Concentration and Recovery of Phospholipids from FOES Using Octadecyl Open Column Chromatograph	91
3.8	Phospholipids Composition of Selected Fraction from Octadecyl Open Column Chromatography	92

LIST OF FIGURES

Figure		Page
1.1	Structure of Phosholipids in Crude Palm Oil	16
1.2	Activities of Phospholipases in Phospholipids	20
2.1	Calibration Curve of Phospholipid-molybdenum Blue Complexes	38
2.2	Concentration of Phospholipids in the Developing Palm Mesocarp	39
2.3	Phospholipid Standards on 2D-TLC Silica Gel Plate	43
2.4	Phospholipids in SW4 by 2D-TLC	44
2.5	Phospholipids in SW20 by 2D-TLC	45
2.6	Chromatogram of Phospholipid Standards by HPLC-ELSD	48
2.7	Calibration Curve of Individual Phospholipid Standard	49
2.8	Phospholipids Composition in the Developing Palm Mesocarp	53
2.9	Phospholipids Profile in Developing Palm Mesocarp	54
2.10	Concentration of β -Sitosterol in the Developing Palm Mesocarp	58
2.11	Concentration of Campesterol in the Developing Palm Mesocarp	59

Figure		Page
2.12	Concentration of Stigmasterol in the Developing Palm Mesocarp	60
2.13	Concentration of Cholesterol in the Developing Palm Mesocarp	61
2.14	Vitamin E Profile for SW Mesocarp Oil of Developing Palm Mesocarp	63
2.15	Carotene Profile for SD Mesocarp Oil of Developing Palm Mesocarp	69
2.16	Concentration of Diacylglycerols in the Developing Palm Mesocarp	73
2.17	Concentration of Triacylglycerols in the Developing Palm Mesocarp	75
2.18	Concentration of Monoacylglycerols in the Developing Palm Mesocarp	76
2.19	Concentration of Free Fatty Acids in the Developing Palm Mesocarp	77
2.20	Concentration of Squalene in the Developing Palm Mesocarp	78
3.1	Phospholipids Profile in FOHS	88
3.2	Phospholipids Profile in FOEDs	88
3.3	Antioxidant activity of Reconstituted Mixture of Phospholipids, Carotenes and Vitamin E	93

LIST OF SCHEMES

Scheme		Page
1.1	Biosynthesis Pathway of Phospholipids and Triacylglycerols	18
2.1	Biosynthesis Pathway of Tocopherols	66
2.2	Biosynthesis Pathway of Tocotrienols	67
2.3	Biosynthesis Pathway of Carotenes in Higher Plants	71

LIST OF ABBREVIATIONS

cm	centimetre
cpo	crude palm oil
° C	degree Celsius
DG	diacylglycerols
DPG	diphosphatidylglycerol
FFA	free fatty acids
FFB	fresh fruit bunches
FRAP	ferric reducing antioxidant power assay
g	gram
GC	gas chromatography
HPLC	high performance liquid chromatography
LPC	lysophosphatidylcholine
LPE	lysophosphatidylethanolamine
max	maximum
mg	milligram
MG	monoacylglycerols
min	minute
ml	mililitre
mm	millimetre
MPOB	Malaysian Palm Oil Board
nm	nanometre
PA	phosphatidic acids

PC	phosphatidylcholine
PE	phosphaditylethanolamine
PG	phosphatidylglycerol
PI	phosphatidylinositol
PL	phospholipids
PM	phosphatidylmethanol
ppm	part per million
PS	phosphatidylserine
SD	sterilised and dried palm mesocarp oil
SW	sterilised and wet palm mesocarp oil
TEAC	trolox equivalent antioxidant capacity
TG	triacylglycerols
TLC	thin layer chromatography
T	trace
UD	unsterilised and dried palm mesocarp oil
UV-Vis	ultraviolet-visible
UW	unsterilised and wet palm mesocarp oil
WAA	weeks after anthesis
wt	weight
μl	microlitre
λ	wavelength