



UNIVERSITI PUTRA MALAYSIA

**FAT MIGRATION OF LAURIC AND NON-LAURIC FAT USED AS
BASE FILLING CENTRE IN DARK CHOCOLATE AT
DIFFERENT STORAGE TEMPERATURES**

ABDELRAHIM ABDELBAGI ALI

FSMB 2001 13

**FAT MIGRATION OF LAURIC AND NON-LAURIC FAT USED AS BASE
FILLING CENTRE IN DARK CHOCOLATE AT DIFFERENT STORAGE
TEMPERATURES**

By

ABDELRAHIM ABDELBAGI ALI

**Thesis Submitted in Fulfilment of the Requirement for the Degree of Doctor of
Philosophy in the Faculty of Food Science and Biotechnology
Universiti Putra Malaysia**

January 2001



DEDICATION

This thesis is dedicated to
my beloved wife Sana,
my children, Mohamad, Zeinab, Ali,
my affectionate parents, brothers and sisters,
for their patience, love and support.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in
fulfilment of the requirement for degree of Doctor of Philosophy

**FAT MIGRATION OF LAURIC AND NON- LAURIC FAT USED AS BASE
FILLING CENTRE IN DARK CHOCOLATE AT DIFFERENT STORAGE
TEMPERATURES**

By

ABELRAHIM ABDELBAGI ALI

January 2001

Chairman: Professor Dr. Jinap Selamat

Faculty: Food Science and Biotechnology

The effects of migration of used filling fats palm kernel stearin (PKS), palm mid-fraction (PMF) and desiccated coconut (DCN) (66% coconut oil) on the physical and chemical characteristics of dark chocolate at different storage temperatures (18°C, 30°C and 35°C) were studied. Fat migration was stimulated in a system by using layers of cream filling and dark chocolates. Total fat content, trigacylglycerol (TAG), fatty acid composition (FAC), solid fat content (SFC), hardness, melting point (MP), polymorphic structure and bloom formation were determined, each week interval for eight weeks. The chocolate samples stored at 18°C showed post-hardening on storage and no indication of softening within two months of storage. There was no significant change in the melting point of chocolate layers (CB). The X-ray diffraction pattern showed that β polymorph dominates in chocolate layers during eight weeks of storage, and the chocolates withstand bloom up to 6 months storage. At 30°C, migration occurred rapidly, giving a

maximum effect in term of hardness, solid fat content, polymorphic structure, and the chocolate bloom after several weeks of storage. Complete deterioration occurred in all chocolate stored at 35°C at the first week of storage. Sensory evaluation indicated that DCN imparts a pleasant flavour to the chocolate. Fractionated PKS or PMF and DCN fillings will be useful if chocolate was stored at a relatively low temperature below 20°C. It can be concluded that a thickness of 3 mm of chocolate could be used for coating of PKS, PMF and PKS+DCN fillings at 18°C. However, at least a 6mm thickness of chocolate is required to coat PMF+DCN centre at 18°C storage.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**MIGRASI LEMAK OLEH MENTENGA-KERAS LAURIK DAN LEMAK
BUKAN LAURIK YANG DIGUNAKAN SEBAGAI LAPISAN PENGISI
TENGAH DI DACAM COKLAT HITAM PADA SUHU PENYIMPANAN YANG
BERBEZA**

Oleh

ABELRAHIM ABDELBAĞI ALI

Januari 2001

Pengerusi: Profesor Jinap Selamat, Ph.D.

Fakulti: Sains Makanan dan Bioteknologi

Kesan migrasi lemak pengisi palm kernel stearin (PKS), palm mid fraction (PMF) dan kelapa parut (DCN) (66% minyak kelapa) ke atas sifat fizikal dan kimia coklat tanpa susu pada suhu penyimpanan yang berbeza (18°C, 30°C, dan 35°C) telah dikaji. Migrasi lemak digalakkan di dalam satu sistem yang menggunakan beberapa lapisan pengisi krim dan coklat tanpa susu. Jumlah lemak, triacylglycerol (TAG), komposisi asid lemak, lemak pejal, kekerasan, takat lebur, struktur polimorfik dan pembentukan bloom dikaji sekali seminggu, selama lapan minggu. Coklat yang disimpan pada suhu 18°C menunjukkan “post hardening” dan tiada kesan kelembutan setelah disimpan selama 2 bulan. Tiada perubahan yang ketara pada takat lebur lapisan coklat. Difraksi sinar-X menunjukkan bahawa polimorf β adalah paling dominan pada lapisan coklat selepas penyimpanan selama 8 minggu dan tiada kesan bloom kelihatan

selama 6 bulan pertama penyimpanan. Pada suhu 30°C, migrasi berlaku dengan cepat mengakibatkan kesan yang maksimum pada kekerasan, jumlah lemak, struktur polimorfik dan bloom coklat setelah penyimpanan selama beberapa minggu. Kerosakan coklat yang disimpan pada 35°C terjadi pada minggu pertama penyimpanan. Penilaian deria rasa menunjukkan bahawa DCN mengakibatkan kerosakan pada citarasa sebenar coklat. PKS atau PMF yang difraksinasi dan DCN boleh bertahan lama apabila coklat disimpan pada suhu di bawah 20°C. Dengan demikian, dapat disimpulkan bahawa ketebalan coklat 3 mm boleh digunakan dalam proses peyalutan menggunakan pengisi PKS, PMF dan PKS+DCN. Sebaliknya, ketebalan coklat sekurang-kurangnya 6 mm diperlukan untuk penyalutan menggunakan pengisi PMF+DCN pada penyimpanan 18°C.

ACKNOWLEDGEMENTS

Thanks to ALMIGHTY ALLAH the most merciful benevolent and beneficial, who enabled me to complete this work in time by sacredness of Holy Prophet MOHAMAD, (peace upon him) who is forever the source of enlightenment, guidance and knowledge for humanity as a whole.

At the very outset, I would like to express my heartiest and sincerest sense of gratitude to my supervisor, Professor Dr. Jinap Selamat, Department of Food Science, Faculty of Food Science and Biotechnology, Universiti Putra Malaysia. Her inspiring guidance, constructive criticism and close supervision throughout my studies and integration of this manuscript, and constant help and useful advises have made life and work easy in Malaysia.

I sincerely and earnestly record my indebtedness to my committee members, Professor Dr. Yaakob B. Che Man, Department of Food Technology, Faculty of Food Science and Biotechnology, Universiti Putra Malaysia, and Dr. Muhamad Suria Affandi Yusof, Malaysian Palm Oil Board, for their advice and guidance during the entire course of study. I would like to thank Mr. Roky Tan, Faculty of Food Science and Biotechnology, UPM, for his useful suggestions which made this work easy and systematic. I would like to record my cordial thanks to Mrs. Nasoi, Abelaziz, Zukarina, Rizuan and Nor-Aini officers from MPOP and my friend Dr. Duncan Reavy, Chechster University, UK, for their continuous help and were always available, also to Dr. Ralph Timms from Britannia Co. UK, for his help and for valuable suggestions.



I would like to express my deepest gratitude to the Ministry of Science (IRPA) (Malaysia) and to the Government of Sudan and Juba University (Sudan) for their support. Last, but not least, no acknowledgment could adequately express my obligation to my wife and my affectionate parents for their spiritual inspiration and mystical guidance which has always motivated me to carry my self through the nobler ideals of life, solving all troubles and boosting my moral to accomplish my goals.



TABLE OF CONTENTS

		Page
DEDICATION.....		2
ABSTRACT.....		3
ABSTRAK.....		5
ACKNOWLEDGEMENTS.....		7
APPROVAL SHEETS.....		9
DECLARATION FORM.....		11
LIST OF TABLES.....		15
LIST OF FIGURES.....		20
LIST OF ABBREVIATIONS.....		23
CHAPTER		
I	GENERAL INTRODUCTION.....	25
II	LITERATURE REVIEW.....	31
	Importance of Fats in Confectionery.....	31
	Effect of Fat Migration in Chocolate.....	32
	Factors Affecting Fat Migration.....	33
	Eutectic and Diluent Interaction Fat Migration (Compatibility)	37
	Cocoa Butter.....	41
	Physical Characteristics of Cocoa Butter.....	42
	Chemical Characteristics of Cocoa Butter	47
	Bloom Formation	50
	Definition.....	50
	Causes of Bloom Formation.....	50
	Prevention of Bloom.....	54
	Properties and Application of Specialty Fats in Chocolates	55
	Lauric Filling Fats Sources.....	56
	Non – Lauric Fat.....	62
III	MATERIALS AND METHODS.....	66
	Raw Materials.....	66
	Methods.....	66
	Chocolate Preparation.....	66
	Preparation of Filling Centre.....	67
	Experimental Design.....	68
	Storage Conditions.....	71
	Sampling.....	71
	Chemical Analysis.....	72
	Physical Analysis.....	75
	Sensory Evaluation	78
	Statistical Analysis.....	79

IV	EFFECT OF STORAGE TEMPERATURE ON THE RATE OF MIGRATION OF PALM KERNEL STEARIN AND PALM MID-FRACTION FROM DARK CHOCOLATE FILLING.....	80
	Introduction.....	80
	Materials and Methods.....	82
	Materials.....	82
	Chocolate and Filling Preparation.....	82
	Experimental Design.....	82
	Storage Conditions and Sampling.....	82
	Chemical Analysis and Physical Analysis	83
	Results and Discussion.....	83
	Characterization of the Fats.....	83
	Chemical Analysis.....	86
	Physical Analysis.....	113
	Sensory Evaluation.....	127
	Conclusion.....	129
V	EFFECT OF DESICCATED COCONUT ON FAT MIGRATION IN DARK CHOCOLATE AT DIFFERENT STORAGE TEMPERATURES.....	131
	Introduction.....	131
	Materials and Methods.....	132
	Materials.....	132
	Chocolate and Filling Preparation.....	133
	Experimental Design	133
	Storage Conditions and Sampling.....	133
	Chemical Analysis and Physical Analysis	133
	Results and Discussion.....	134
	Effect of DCN on the Physical and Chemical Properties of PKS and PMF	134
	Chemical Analysis.....	137
	Physical Analysis.....	161
	Sensory Analysis.....	174
	Conclusion.....	177
VI	POLYMORPHIC CHANGES OF COCOA BUTTER DUE TO THE MIGRATION OF PKS, PMF AND COCONUT FATS FROM THE FILLING CENTRE INTO THE DARK CHOCOLATE	179
	Introduction.....	179
	Material and Methods.....	180
	Materials.....	180
	Chocolate Preparation.....	181
	Filling Preparation.....	181

Experimental Design.....	181
Storage Conditions.....	181
Sampling.....	181
Determination Melting Point.....	182
Determination of the Polymorphic Structure	182
Results and Discussion.....	182
Melting Point.....	182
Polymorphic Structure.....	191
Conclusion.....	206
VII GENERAL DISCUSSION AND CONCLUSION	208
BIBLIOGRAPHY	216
APPENDICES.....	226
BIODATA OF THE AUTHOR.....	261

LIST OF TABLES

Table		Page
1	Classification and temperature (°C) of cocoa butter crystalline forms.....	43
2	Fatty acid composition (Wt %) of cocoa butter	49
3	Triacylglycerols composition (%) of cocoa butter.....	49
4	Appearance, causes and prevention of bloom formation in chocolates	53
5	Chemical properties of PKS.....	59
6	Comparison between palm kernel oil and coconut oil triacylglycerols ...	63
7	Fatty Acid Composition (%) of CB, PKS, PMF and CNO (%).....	84
8	Carbon number profile (CNP) (%) of CB, PKS, PMF and CNO.....	84
9	Solid fat content (%) and melting point °C of CB, PKS, PMF and CNO.	85
10	Fat contents (%) in the coating and filling of PKS-filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks.....	87
11	Fat contents (%) in the coating and filling of PMF-filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks.....	88
12	Effect of temperature on the migration of lauric acid (%) in PKS -filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks	96
13	Effect of temperature on the migration of palmitic acid (%) in PMF-filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks...	97
14	Effect of storage temperature on fat bloom in PKS-filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks	114
15	Effect of storage temperature on fat bloom in PMF-filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks	115
16	Effect of temperature on the hardness of PKS-filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks	118

17	Effect of temperature on the hardness of PMF-filled dark chocolate stored at 18°C, 30°C and 35°C for eight weeks	121
18	Sensory evaluation of PKS and PMF-filled dark chocolates stored at 18°C and 30°C for eight weeks	127
19	Triacylglycerols composition (%) of CB, PMF+DCN and PKS+DCN...	136
20	Solid fat content (%) and melting point (°C) of the CB, PMF+DCN and PKS+DCN.....	136
21	Migration of lauric acid from the PKS+ DCN-filled centre into the chocolate coating at different distances stored at 18°C and 30°C for eight weeks	145
22	Migration of lauric acid from the PMF+ DCN-filled centre into the chocolate coating at different distances stored at 18°C and 30°C for eight weeks	147
23	Induction of bloom in PKS + DCN-filled dark chocolate stored at 18°C and 30°C for eight weeks	162
24	Induction of bloom in PMF + DCN-filled dark chocolate stored at 18°C and 30°C for eight weeks	163
25	Effect of temperature on the hardness of PKS + DCN-filled dark chocolate stored at 18°C and 30°C for eight weeks	167
26	Effect of temperature on the hardness of PMF + DCN-filled dark chocolate stored at 18°C and 30°C for eight weeks	168
27	Sensory evaluation of PKS+DCN and PMF + DCN-filled dark chocolate stored at 18°C and 30°C for eight weeks	175
28	X-ray diffraction pattern of PKS-filled dark chocolate filled stored at 18°C for eight weeks by X-ray diffractometer after stabilization (at 26°C for 40hr).....	192
29	X-ray diffraction pattern of PKS-filled dark chocolate filled stored at 30°C for eight weeks by X-ray diffractometer after stabilization (at 26°C for 40hr).....	193
30	X-ray diffraction pattern of PKS-filled dark chocolate filled stored at 35°C for eight weeks by X-ray diffractometer after stabilization (at 26°C for 40hr).....	194

31	X-ray diffraction pattern of PMF-filled dark chocolate filled stored at 18°C for eight weeks by X-ray diffractometer after stabilization (at 26°C for 40hr).....	196
32	X-ray diffraction pattern of PMF-filled dark chocolate filled stored for eight weeks at 30°C by X-ray diffractometer after stabilization (at 26°C for 40hr).....	197
33	X-ray diffraction pattern of PMF-filled dark chocolate filled stored for eight weeks at 35°C by X-ray diffractometer after stabilization (at 26°C for 40hr).....	198
34	X-ray diffraction pattern of PKS+DCN-filled dark chocolate filled stored for eight weeks at 18°C by X-ray diffractometer after stabilization (at 26°C for 40hr).....	201
35	X-ray diffraction pattern of PKS+DCN-filled dark chocolate filled stored for eight weeks at 30°C by X-ray diffractometer after stabilization (at 26°C for 40hr).....	202
36	X-ray diffraction pattern of PMF+DCN-filled dark chocolate filled stored for eight weeks at 18°C by X-ray diffractometer after stabilization (at 26°C for 40hr).....	203
37	X-ray diffraction pattern of PMF+DCN-filled dark chocolate filled stored for eight weeks at 30°C by X-ray diffractometer after stabilization (at 26°C for 40hr).....	204
38	Change in fatty acid composition of dark chocolate PKS-filled stored at 18°C for eight weeks	227
39	Change in fatty acid composition of dark chocolate PKS-filled stored at 30°C for eight weeks	228
40	Change in fatty acid composition of dark chocolate PKS-filled stored at 35°C for eight weeks	229
41	Change in fatty acid composition of dark chocolate PMF-filled stored at 18°C for eight weeks	230
42	Change in fatty acid composition of dark chocolate PMF-filled stored at 30°C for eight weeks	231
43	Change in fatty acid composition of dark chocolate PMF-filled stored at 35°C for eight weeks	232

44	Change in triacylglycerols of PKS-filled dark chocolate stored at 18°C for eight weeks	233
45	Change in triacylglycerols of PKS-filled dark chocolate stored at 30°C for eight weeks	234
46	Change in triacylglycerols of PKS-filled dark chocolate stored at 35°C for eight weeks	235
47	Change in triacylglycerols of PMF-filled dark chocolate stored at 18°C for eight weeks	236
48	Change in triacylglycerols of PMF-filled dark chocolate stored at 30°C for eight weeks	237
49	Change in triacylglycerols of PMF-filled dark chocolate stored at 35°C for eight weeks	238
50	Change in solid fat content (SFC) of PKS-filled dark chocolate stored at 18°C for eight weeks	241
51	Change in solid fat content (SFC) of PKS-filled dark chocolate stored at 30°C for eight weeks	242
52	Change in solid fat content (SFC) of PKS-filled dark chocolate stored at 35°C for eight weeks	243
53	Change in solid fat content (SFC) of PMF-filled dark chocolate stored at 18°C for eight weeks	244
54	Change in solid fat content (SFC) of PMF-filled dark chocolate stored at 30°C for eight weeks	245
55	Change in solid fat content (SFC) of PMF-filled dark chocolate stored at 35°C for eight weeks	246
56	Change in fatty acid composition of dark chocolate PKS+DCN-filled stored at 18°C for eight weeks	249
57	Change in fatty acid composition of dark chocolate PKS+DCN-filled stored at 30°C for eight weeks	250
58	Change in fatty acid composition of dark chocolate PMF+DCN-filled stored at 18°C for eight weeks	251

59	Change in fatty acid composition of dark chocolate PMF+DCN-filled stored at 30°C for eight weeks	252
60	Change in triacylglycerols of PKS+DCN-filled dark chocolate stored at 18°C for eight weeks	253
61	Change in triacylglycerols of PKS+DCN-filled dark chocolate stored at 30°C for eight weeks	254
62	Change in triacylglycerols of PMF+DCN-filled dark chocolate stored at 18°C for eight weeks	255
63	Change in triacylglycerols of PMF+DCN-filled dark chocolate stored at 30°C for eight weeks	256
64	Change in solid fat content (SFC) of PKS+DCN-filled dark chocolate stored at 18°C for eight weeks	257
65	Change in solid fat content (SFC) of PKS+DCN-filled dark chocolate stored at 30°C for eight weeks	258
66	Change in solid fat content (SFC) of PMF+DCN-filled dark chocolate stored at 18°C for eight weeks	259
67	Change in solid fat content (SFC) of PMF+DCN-filled dark chocolate stored at 30°C for eight weeks	260

LIST OF FIGURES

Figure		Page
1	Isosolids phase diagram for cocoa butter and lauric hard butter	40
2	Isosolids phase diagram for cocoa butter and cocoa butter equivalent....	40
3	Solid fat content (%) of palm kernel stearin (PKS), palm mid-fraction (PMF) and cocoa butter (CB).....	60
4	Layout of the experimental design.....	69
5	Dark chocolate and the filling layers.....	70
6	Influence of storage temperature on PKS migration	90
7	Influence of storage temperature on PMF migration	91
8	Effect of storage temperature on the specific migration index (SMI) (%) of PKS-filled dark chocolate stored for eight weeks	99
9	Changes in the triacylglycerol composition of PKS-filled dark chocolate stored at 18°C for eight weeks	100
10	Changes in the triacylglycerol composition of PKS-filled dark chocolate stored at 30°C for eight weeks	101
11	Changes in the triacylglycerol composition of PKS-filled dark chocolate stored at 35°C for eight weeks	102
12	Effect of storage temperature on the specific migration index (SMI) (%) of PMF-filled dark chocolate stored for eight weeks.....	106
13	Changes in the triacylglycerol composition of PMF-filled dark chocolate stored at 18°C for eight weeks	107
14	Changes in the triacylglycerol composition of PMF-filled dark chocolate stored at 30°C for eight weeks	108
15	Changes in the triacylglycerol composition of PMF-filled dark chocolate stored at 35°C for eight weeks	109

16	Effect of storage temperature on the rate of movement of LLL C36) in PKS-filled dark chocolate filled stored for eight week	111
17	Effect of storage temperature on the rate of movement of POP (C50) in PMF-filled dark chocolate filled stored for eight week	112
18	The bloom formation of PKS-filled dark chocolate filled with stored at 18°C and 30°C for eight weeks.....	116
19	The bloom formation of PMF-filled dark chocolate filled with stored at 18°C and 30°C for eight weeks.....	116
20	SFC (%) of PKS and control (CB) and PKS-filled dark chocolate stored at 18°C and 30°C and 35°C eight weeks.....	125
21	SFC (%) of PMF and control (CB) and PMF-filled dark chocolate stored at 18°C and 30°C and 35°C eight weeks.....	126
22	Total fat content (%) of PKS + DCN-filled dark filled chocolate stored at 18°C for eight weeks.	140
23	Total fat content (%) of PMF + DCN-filled dark filled chocolate stored at 18°C for eight weeks.	141
24	Total fat content (%) of PKS + DC-filled dark filled chocolate stored at 30°C for eight weeks.	142
25	Total fat content (%) of PMF + DCN-filled dark filled chocolate stored at 30°C for eight weeks.	143
26	Changes in the triacylglycerol Composition of PKS + DCN-filled dark Chocolate stored at 18°C for eight weeks.....	150
27	Changes in the triacylglycerol composition of PKS + DCN-filled dark Chocolate stored at 30°C for eight weeks.....	151
28	Effect of storage temperature on the specific migration index (SMI) of PKS + DCN-filled dark chocolate	152
29	Changes in the triacylglycerol composition of PMF + DCN-filled dark chocolate stored at 18°C for eight weeks.....	154
30	Changes in the triacylglycerol composition of PMF + DCN-filled dark chocolate stored at 30°C for eight weeks.....	155

31	Effect of storage temperature on the specific migration index (SMI) of PMF+DCN used as base filling centre in dark chocolate.....	156
32	Rate of change of trilaurin (C36) in the PKS+DCN-filled dark chocolate stored at 18°C and 30°C for eight weeks	159
33	Rate of change of trilaurin (C36) in the PMF+DCN-filled dark chocolate stored at 18°C and 30°C for eight weeks	160
34	The bloom formation of PKS+DCN or PMF+DCN-filled dark chocolate stored for at 18°C and 30°C eight weeks	165
35	Solid fat content (%) of CB, PKS, PKS + DCN and extracted fats from dark chocolate stored at 18°C and 30°C for eight weeks	171
36	Solid fat content (%) of CB, PMF, PMF + DCN and extracted fats from dark chocolate stored at 18°C and 30°C for eight weeks	173
37	Melting point differential scanning calorimeter (DSC) of CB, PKS, and chocolate filled with PKS stored at 18°C, 30°C and 35°C after eight weeks.....	184
38	Melting point differential scanning calorimeter (DSC) of CB, PMF, and chocolate filled with PKS stored at 18°C, 30°C and 35°C after eight weeks...	186
39	Melting point differential scanning calorimeter (DSC) of CB, PKS, PKS+DCN and chocolate filled with PKS+DCN stored at 18°C and 30°C after eight weeks.....	189
40	Melting point differential scanning calorimeter (DSC) of CB, PMF, PMF+DCN and chocolate filled with PKS+DCN stored at 18°C and 30°C after eight weeks.....	190
41	Relationship between hardness and SFC of dark chocolate PKS filling at 18°C	239
42	Relationship between hardness and SFC of dark chocolate PMF filling at 18°C.....	240
43	Relationship between instrumental and sensory evaluation hardness	247

LIST OF ABBREVIATIONS

CB	cocoa butter
CBE	cocoa butter equivalent
CBS	cocoa butter substitute
CBX	cocoa butter extender
PKS	palm kernel stearin
FHPKO	fractionated hydrogenated palm kernel oil
PMF	palm mid-fraction
CNO	coconut oil
DCN	desiccated coconut
HPLC	high performance liquid chromatography
GC	gas chromatography
DSC	differential scanning calorimeter
NMR	nuclear magnetic resonance
SFC	solid fat content
SMI	specific migration index
LFC	liquid fat content
TFC	total fat content
RC	rate of change
MPOB	Malaysia Palm Oil Board
FAME	fatty acid methyl ester
FAC	Fatty acid composition

TFC	total fat content
mm	millimeter
MP	melting point
IV	Iodine value
TAG	triacylglycerol
POP	Palmitic-oleic-palmitic
POS	Palmitic-oleic-stearic
SOS	stearic-oleic-stearic
LLL	lauric-lauric-lauric
LLM	Lauric-lauric-myristic