



UNIVERSITI PUTRA MALAYSIA

**EFFECT OF FISH PROTEINS, SALT, SUGAR AND MONOSODIUM
GLUTAMATE ON THE MICROSTRUCTURAL, RHEOLOGICAL AND
PHYSICO-CHEMICAL PROPERTIES OF FISH CRACKER
(‘KEROPOK’)**

CHEOW CHONG SENG

FSMB 1998 16

**EFFECT OF FISH PROTEINS, SALT, SUGAR AND MONOSODIUM
GLUTAMATE ON THE MICROSTRUCTURAL, RHEOLOGICAL AND
PHYSICO-CHEMICAL PROPERTIES OF FISH CRACKER ('KERPOK')**

By

CHEOW CHONG SENG

**Dissertation Submitted in Fulfilment of the Requirements for the
Degree of Doctor of Philosophy in the Faculty of
Food Science and Biotechnology,
Universiti Putra Malaysia**

July 1998



ACKNOWLEDGEMENTS

I would like to express my deepest appreciation and gratitude to the Chairman of my supervisory committee, Prof Dr Yu Swee Yean for her understanding, patience, invaluable guidance, suggestions, and constant encouragement throughout the planning and execution of the research. My grateful thanks are also to Dr Nazlin K Howell, Reader in Food Science, School of Biological Sciences, University of Surrey, Guildford, England, member of supervisory committee for her guidance, suggestions, and arrangement of research work in University of Surrey, England for four months. The support, suggestions and insightful comments given by the members of my supervisory committee, Prof Dr Yaakob Che Man and Dr Sharifah Kharidah Syed Muhammed are gratefully acknowledged.

My thanks and appreciation are also due to the former dean, Prof Datuk Dr Mohd Mahyuddin Dahan and Prof Dr Gulam Rusul Rahmat Ali, present dean, Faculty of Food Science and Biotechnology for their support and advice. The insightful information and guidance extended by Encik Dzulkifly Mat Hashim is duly acknowledged.

I would like to thank Mr Ho Oi Kuan, Electron Microscopy Division, Institute of Bioscience for his technical assistance in the microscopy work. Thanks



are also due to Mr Kyaw Zay Ya for helping in part of the experimental work and preliminary discussion

I am grateful to Miss Lai Oi Ming for her help during the preparation of this dissertation I would also like to thank the laboratory assistants who have helped me, especially, Mr Chan Tin Wan, Encik Mohd Suib b Yusof, Encik Rosli Aslim, Encik Razali Othman, Encik Mohd Amran, Encik Zulkifli Nordin, Puan Siti Shahrul, Puan Siti Ziryani and Encik Mustafa Marzuki My sincere gratitude is also extended to Institut Teknologi Mara for granting the study leave and scholarship during my study

Last but not least, I am greatly indebted to my beloved wife and sons for their understanding and encouragement throughout the course of this study

I would also like to thank all my friends who gave me the encouragement to initiate and complete the study To them and all others who have helped during this study, I wish to express my deepest appreciation

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS.....	ii
LIST OF TABLES.....	viii
LIST OF FIGURES.....	ix
LIST OF PLATES.....	xii
LIST OF ABBREVIATION.....	xvii
ABSTRACT.....	xix
ABSTRAK.....	xxi
 CHAPTER	
1 GENERAL INTRODUCTION.....	1
2 LITERATURE REVIEW.....	6
‘Keropok’ Production Technology.....	6
Traditional Method.....	6
Modified Method.....	8
Extrusion Method.....	9
Important Quality Aspects of ‘Keropok’.....	10
Extrusion Technology.....	13
Effect of Protein on Starch Expansion.....	14
Effect of Amylose and Amylopectin Contents of Starch on Starch Expansion.....	17
Effect of Water on Starch Expansion.....	18
Effect of Salt and Sugar on Starch Expansion.....	19
Starch Gelatinisation.....	21
Factors Influencing Starch Gelatinisation.....	23
Rheology of Gels.....	32
Small Deformation Tests.....	32
Large Deformation Tests.....	35
Starch Gelatinisation and Gelation.....	37
Small Deformation (Dynamic Viscoelastic Properties) of Gels.....	39
Factors Affecting Viscoelastic Properties of Starch Gel.....	39
Viscoelastic Properties of Fish Gel.....	44
Preparation of Gels for Small Deformation.....	46
Large Deformation Test.....	48
Starch Gels.....	48



	Fish Gels.....	50
	Effect of Starches on Large Deformation of Surimi.....	51
	Effect of Salt on Large Deformation of Surimi.....	54
	Effect of Non-muscle Protein on Large Deformation of Surimi.....	55
	Microscopy.....	57
	Surimi.....	57
	Structure of Extruded Products by Scanning Electron Microscopy.....	63
3	DIFFERENTIAL SCANNING CALORIMETRY (DSC) OF FISH PROTEIN-STARCH MIXTURES.....	67
	Introduction.....	67
	Materials and Methods.....	69
	Raw Materials.....	69
	Preparation of Fish-Starch Paste	70
	Differential Scanning Calorimetry (DSC).....	70
	Statistical Analysis of Data.....	71
	Results and Discussion	72
	Variation of Gelatinisation Temperatures with the Addition of 2% Salt, 1% Sugar and 0.4% MSG.....	72
	Effect of Salt, Sugar and MSG on Gelatinisation of Starches.....	83
	Conclusion.....	94
	Summary.....	94
4	STRUCTURE AND EXPANSION OF 'KEROPOK'.....	96
	Introduction.....	96
	Materials and Methods.....	97
	Raw Materials.....	97
	Processing of 'Keropok'	98
	Microscopy Methods.....	99
	Linear Expansion of 'Keropok'	101
	Statistical Analysis of Data.....	102
	Results and Discussion.....	102
	Effect of Mixing and Fish Quality on Expansion.....	102
	Light Microscopy Study of the Steamed Gels and Expanded 'Keropok'	105
	Scanning Electron Microscopy Study of Expanded 'Keropok'	113
	Transmission Electron Microscopy Study of Steamed Gel and Expanded 'Keropok'	119
	Linear Expansion of 'Keropok'	125

Conclusion.....	129
Summary.....	129
5 VISCOELASTIC PROPERTIES OF ‘KEROPOK’ GEL.....	131
Introduction.....	131
Materials and Methods.....	134
Raw Materials.....	134
Preparation of Fish-Starch Paste.....	134
Rheological Measurements.....	135
Light Microscopy.....	136
Statistical Analysis of Data.....	136
Results and Discussion	137
Effect of 2% Salt and Combination of 2% Salt, 1% Sugar and 0.4% MSG on the Viscoelastic Properties of Fish-Starch Gel.....	139
Effect of Salt, Sugar, and MSG on the Viscoelastic Properties of Fish-Starch Gel.....	151
Conclusion.....	156
Summary.....	157
6 LARGE DEFORMATION OF ‘KEROPOK’ GEL.....	158
Introduction.....	158
Materials and Methods.....	160
Raw Materials.....	160
Processing of ‘Keropok’	160
Light Microscopy.....	161
Gel Testing.....	161
Statistical Analysis of Data.....	162
Results and Discussion	162
Penetration Test of Hot ‘Keropok’ Gels Containing 1% Sugar, 0.4% MSG, and Different % of Salt.....	162
Compressive Stress of Gel after Hot Gels Containing 1% Sugar, 0.4% MSG, and 0 or 2% Salt.....	167
Compressive Stress of Gel after Chilled for One Hour at 0°C.....	169
Compressive Stress of Gel after Chilled for One Day at 4°C.....	171
Comparison of Compressive Stresses of Gels with 2% Salt, 2% Sugar, 2% MSG and Combination of 2% Salt, 1% Sugar, 0.4% MSG.....	173
Conclusion.....	176
Summary.....	177



7	SUMMARY, CONCLUSIONS, AND RECOMMENDATION.....	178
	Summary	178
	Conclusions and Recommendations.....	181
	BIBLIOGRAPHY.....	183
	APPENDIX.....	199
	BIOGRAPHICAL SKETCH.....	210
	PAPERS PUBLISHED FROM THE DISSERTATION.....	211



LIST OF TABLES

Table		Page
1	Transition Temperature of Fish and Pure Starches	75
2	Enthalpies of Gelatinisation of Dry Tapioca Starch in Fish-Tapioca Starch Mixtures with Different Amounts of Salt, Sugar and MSG	79
3	Enthalpies of Gelatinisation of Dry Sago Starch in Fish-Sago Starch Mixtures with Different Amounts of Salt, Sugar and MSG	80
4	Moisture Content of Fish-Tapioca Starch Mixtures with Different Amounts of Salt, Sugar and MSG	81
5	Moisture Content of Fish-Sago Starch Mixtures with Different Amounts of Salt, Sugar and MSG	82
6	Weights of Ice (g) Added to 1 Kg 'Keropok' Mixtures	98



LIST OF FIGURES

Figure		Page
1	Effect of 2% Salt, 1% Sugar, 0 4% MSG and Fish Content on the Gelatinisation of Fish-Tapioca Starch Mixtures	73
2	Effect of 2% Salt, 1% Sugar, 0 4% MSG and Fish Content on the Gelatinisation of Fish-Sago Starch Mixtures	74
3	Effect of 2% Salt, 1% Sugar, 0 4% MSG and Fish Content on the DSC Thermograms of Fish-Tapioca Starch Mixtures	77
4	Effect of 2% Salt, 1% Sugar, 0 4% MSG and Fish Content on the DSC Thermograms of Fish-Sago Starch Mixtures	78
5	Effect of 2% Salt, 2% Sugar, 2% MSG and Fish Content on the Onset Gelatinisation Temperatures (T_o) of Fish-Tapioca Starch Mixtures	84
6	Effect of 2% Salt, 2% Sugar, 2% MSG and Fish Content on the Peak Gelatinisation Temperatures (T_p) of Fish-Tapioca Starch Mixtures	85
7	Effect of 2% Salt, 2% Sugar, 2% MSG and Fish Content on the Onset Gelatinisation Temperatures (T_o) of Fish-Sago Starch Mixtures	86
8	Effect of 2% Salt, 2% Sugar, 2% MSG and Fish Content on the Peak Gelatinisation Temperatures (T_p) of Fish-Sago Starch Mixtures	87
9	Effect of Salt, Sugar, MSG, Their Combination and Fish Content on the Onset Gelatinisation Temperatures (T_o) of Fish-Tapioca Starch Mixtures	90
10	Effect of Salt, Sugar, MSG, Their Combination and Fish Content on the Peak Gelatinisation Temperatures (T_p) of Fish-Tapioca Starch Mixtures	91



11	Effect of Salt, Sugar, MSG, Their Combination Content on the Onset Gelatinisation Temperatures (T_o) of Fish-Sago Starch Mixtures	92
12	Effect of Salt, Sugar, MSG, Their Combination Content on the Peak Gelatinisation Temperatures (T_p) of Fish-Sago Starch Mixtures	93
13	Effect of Various Fish Content at Different Salt Contents on the Linear Expansion of Expanded 'Keropok'	126
14	Log-Log Plot of G' , G'' Versus Frequency	138
15	Effect of 2% Salt, Combination of 2% Salt, 1% Sugar, 0.4% MSG on G' of 'Keropok' Gels with Different Fish Contents	140
16	Effect of 2% Salt, Combination of 2% Salt, 1% Sugar, 0.4% MSG on $\tan \delta$ of 'Keropok' Gels with Different Fish Contents	141
17	Effect of 2% Salt, Combination of 2% Salt, 1% Sugar, 0.4% MSG on n of 'Keropok' Gels with Different Fish Contents	142
18	Effect of Temperature and 2% Salt on G' of 'Keropok' Gels with Different Fish Contents	148
19	Effect of Temperature and 2% Salt on $\tan \delta$ of 'Keropok' Gels with Different Fish Contents	149
20	Effect of Temperature and 2% Salt on n of 'Keropok' Gels with Different Fish Contents	150
21	Effect of 2% Salt, 2% Sugar and 2% MSG on G' of 'Keropok' Gels with Different Fish Contents	152
22	Effect of 2% Salt, 2% Sugar and 2% MSG on δ of 'Keropok' Gels with Different Fish Contents	153
23	Effect of 2% Salt, 2% Sugar and 2% MSG on n of 'Keropok' Gels with Different Fish Contents	154
24	Effect of Salt and Fish Content on the Maximum Penetration Force of 'Keropok' Gel	163

25	Effect of Salt and Fish Content on the Slope of In Force-Time Deformation Curve (Measure Of El 'Keropok' Gel	166
26	Effect of Salt and Fish Content on Compressive Stress of Hot 'Keropok' Gel	168
27	Effect of Salt and Fish Content on Compressive Stress of 'Keropok' Gel after Chilled for One Hour	170
28	Effect of Salt and Fish Content on Compressive Stress of 'Keropok' Gel after Chilled for One Day	172
29	Effect of 2% Salt, 2% Sugar, 2% MSG and Combination of 2% Salt, 1% Sugar, 0 4% MSG on Compressive Stress of Hot 'Keropok' with Different Fish Content	174
30	Effect of 2% Salt, 2% Sugar, 2% MSG on Compressive Stress of 'Keropok' Gel with Different Fish Content for Different Time of Storage	175



LIST OF PLATES

Plate		Page
1	Light Photomicrograph of Steamed Gel with 50% Fish, 2% Salt, 1% Sugar, 0 4% MSG, Improper Mixing, Showing Uneven Distribution of Fish Protein Aggregates	103
2	Light Photomicrograph of Expanded 'Keropok' with 80% Fish without Salt, Showing Uneven Distribution of Fish Protein	103
3	Light Photomicrograph of Steamed Gel with 60% Fish, 2% Salt, 1% Sugar, 0 4% MSG (5 Minutes of Mixing), Showing Uneven Distribution of Fish Protein	104
4	Light Photomicrograph of Steamed Gel with 60% Fish, 2% Salt, 1% Sugar, 0 4% MSG (10 Minutes of Mixing), Showing Uneven Distribution of Fish Protein	104
5	Light Photomicrograph of Steamed Gel with 20% Fish, 2% Salt, 1% Sugar, 0 4% MSG, Showing the Even Distribution of Fish Muscle Fibres	107
6	Light Photomicrograph of Steamed Gel with 30% Fish, 2% Salt, 1% Sugar, 0 4% MSG, Showing the Even Distribution of Fish Muscle Fibres	107
7	Light Photomicrograph of Steamed Gel with 40% Fish, 2% Salt, 1% Sugar, 0 4% MSG, Showing the Even Distribution of Fish Muscle Fibres	108
8	Light Photomicrograph of Steamed Gel with 50% Fish, 2% Salt, 1% Sugar, 0 4% MSG, Showing the Even Distribution of Fish Muscle Fibres	108
9	Light Photomicrograph of Steamed Gel with 60% Fish, 2% Salt, 1% Sugar, 0 4% MSG, Showing the Fish Muscle Fibres Forming Network	109



10	Light Photomicrograph of Steamed Gel with 70% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing a Complete Network of Fish Muscle Fibres	109
11	Light Photomicrograph of Steamed Gel with 80% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing a Complete Network of Thick Fish Muscle Fibres	110
12	Light Photomicrograph of Steamed Gel with 90% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing a Complete Network of Thick Fish Muscle Fibres	110
13	Light Photomicrograph of Expanded 'Keropok' with 40% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing the Broken Fish Muscle Fibres Surrounding the Air Cells	111
14	Light Photomicrograph of Expanded 'Keropok' with 50% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing the Broken Fish Muscle Fibres Surrounding the Air Cells	111
15	Light Photomicrograph of Expanded 'Keropok' with 60% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing the Fish Muscle Fibres Surrounding the Air Cells	112
16	Light Photomicrograph of Expanded 'Keropok' with 50% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Improper Mixing, Showing the Fish Aggregates	112
17	Light Photomicrograph Of Expanded 'Keropok' with 70% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Improper Mixing, Showing the Fish Aggregates	114
18	Light Photomicrograph Of Expanded 'Keropok' With 60% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing Fish Muscle Fibres Surrounding the Air Cell	114
19	Light Photomicrograph of Expanded 'Keropok' with 70% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing the Continuous Fish Muscle Fibres Surrounding the Air Cells	115
20	Light Photomicrograph of Expanded 'Keropok' with 80% Fish, 2% Salt, 1% Sugar, 0.4% MSG, Showing the Continuous Thick Fish Muscle Fibres Surrounding the Air Cells	115



21	Light Photomicrograph of Expanded 'Keropok' with 90% Fish, 2% Salt, 1% Sugar, 0 4% MSG, Showing the Thick Fish Muscle Fibres Blocking Starch Expansion	116
22	SEM Photomicrograph of Expanded 'Keropok' Containing Pure Tapioca Starch	117
23	SEM Photomicrograph of Expanded 'Keropok' Containing 10% Fish, 2% Salt, 1% Sugar, 0 4% MSG	117
24	SEM Photomicrograph of Expanded 'Keropok' Containing 20% Fish, 2% Salt, 1% Sugar, 0 4% MSG	118
25	SEM Photomicrograph of Expanded 'Keropok' Containing 30% Fish, 2% Salt, 1% Sugar, 0 4% MSG	118
26	SEM Photomicrograph of Expanded 'Keropok' Containing 50% Fish, 2% Salt, 1% Sugar, 0 4% MSG	120
27	SEM Photomicrograph of Expanded 'Keropok' Containing 60% Fish, 2% Salt, 1% Sugar, 0 4% MSG	120
28	SEM Photomicrograph of Expanded 'Keropok' Containing 70% Fish, 2% Salt, 1% Sugar, 0 4% MSG	121
29	SEM Photomicrograph of Expanded 'Keropok' Containing 60% Fish, 2% Salt, 1% Sugar, 0 4% MSG	121
30	SEM Photomicrograph of Expanded 'Keropok' Containing 60% Fish, 2% Salt, 1% Sugar, 0 4% MSG	122
31	SEM Photomicrograph of Expanded 'Keropok' Containing 60% Fish, 0% Salt, 1% Sugar, 0 4% MSG	122
32	Transmission Electron Microscopy of Expanded 'Keropok' with 70% Fish, 0% Salt, 1% Sugar, 0 4% MSG	123
33	Transmission Electron Microscopy of Steamed Gel with 30% Fish, 2% Salt, 1% Sugar, 0 4% MSG	123
34	Transmission Electron Microscopy of Steamed Gel with 80% Fish, 2% Salt, 1% Sugar, 0 4% MSG	124
35	Transmission Electron Microscopy of Expanded 'Keropok' with 70% Fish, 1% Salt, 1% Sugar, 0 4% MSG	124

36	Light Photomicrograph of Gel Containing 30% Cod Fish, 2% Salt, 1% Sugar and 0.4% MSG, Showing the Even Distribution of Fish Muscle Fibres	143
37	Light Photomicrograph of Gel Containing 50% Cod Fish, 2% Salt, 1% Sugar and 0.4% MSG, Showing the Even Distribution of Fish Muscle Fibres	143
38	Light Photomicrograph of Gel Containing 70% Cod Fish, 2% Salt, 1% Sugar and 0.4% MSG, Showing the Network of Fish Muscle Fibres	144
39	Light Photomicrograph of Gel Containing 50% Cod Fish and 2% Salt, Showing the Network of Fine Fish Muscle Fibres	144
40	Light Photomicrograph of Gel Containing 70% Cod Fish and 2% Salt, Showing the Network of Fine Fish Muscle Fibres	147
41	Light Photomicrograph of Gel Containing 70% Cod Fish and 2% Sugar, Showing Lumps of Fish Muscle Fibres	147
42	Light Photomicrograph of Gel Containing 70% Fish and 2% MSG, Showing Joining of Fish Protein Strands	155
43	Light Photomicrograph of Gel Containing 70% Fish without Salt, Sugar and MSG, Showing Lumps of Fish Aggregates	155
44	Light Photomicrograph of Gel Containing 70% Fish and 1% Salt, 1% Sugar, 0.4% MSG, Showing Partial Joining of Fish Muscle Fibres	165
45	Light Photomicrograph of Gel Containing 70% Fish and 2% Salt, Showing the Network of Fine Fish Muscle Fibres	165
46	Silver Jewfish, <i>Johmus Soldado</i>	200
47	Bowl Chopper	200
48	Stuffer	201
49	Steamer	202
50	'Keropok' Chilled Overnight In Chilled Room	202



51	Dried 'Keropok'	203
52	Differential Scanning Calorimeter	204
53	Rheometer	204
54	Light Microscope with Camera	205
55	Critical Point Dryer	206
56	Microtome	206
57	Scanning Electron Microscope	207
58	Transmission Electron Microscope	208
59	Steven LFRA Texture Analyser	209

LIST OF ABBREVIATIONS AND SYMBOLS

δ	delta
G'	storage modulus
G''	loss modulus
G^*	complex shear modulus
η^*	complex viscosity
ω	frequency, radian/s
n	slope of log-log plot of G' versus frequency
T_o	onset gelatinization temperature
T_p	peak gelatinization temperature
T_c	conclusion gelatinization temperature
ϑ_s	starch fraction of mixed gel of cassava starch and whey protein isolate
Hz	cycle/second
kPa	kiloPascal, kN/m^2
rev/min	revolution per minute
AR	Analytical Reagent
BSA	bovine serum albumin
DSC	Differential Scanning Calorimetry
ESP	egg white powder
LM	Light Microscopy



MSG	monosodium glutamate
m c	moisture content
SEM	Scanning Electron Microscopy
SPI	soya protein isolate
TEM	Transmission Electron Microscopy
w/v	weight/volume basis
w/w	weight/weight basis
YPC	yeast protein concentrate



Abstract of the Dissertation presented to the Senate of Universiti Putra Malaysia in fulfilment of the Requirements for the Degree of Doctor of Philosophy.

EFFECT OF FISH PROTEINS, SALT, SUGAR AND MONOSODIUM GLUTAMATE ON THE MICROSTRUCTURAL, RHEOLOGICAL AND PHYSICO-CHEMICAL PROPERTIES OF FISH CRACKER ('KEROPOK')

By

CHEOW CHONG SENG

July 1998

Chairman : Professor Yu Swee Yean, Ph. D.

Faculty : Food Science and Biotechnology

Fish cracker or more commonly known as 'keropok' in Malaysia is a popular snack food among countries in the ASEAN region. This work examines factors affecting 'keropok' quality such as the effect of fish proteins, salt, sugar, monosodium glutamate (MSG) on the gelatinisation of tapioca and sago starches. Microstructural studies of 'keropok' during different stages of processing were also observed and correlated to rheological behaviour.

Results from differential scanning calorimetry (DSC) showed that with increasing fish content the conclusion gelatinisation temperature (T_c) of the mixture remained relatively constant while the range of gelatinisation temperature decreased. There were hardly any effect due to the addition of 1% sugar and 0.4% MSG, on the onset (T_o) and peak (T_p) gelatinisation temperatures of sago and tapioca starches. The addition of 2% salt had the greatest effect on gelatinisation temperature of



'keropok' mixture, linear expansion of fried 'keropok', and small and large deformations of 'keropok' gel. The technology of producing a good expanded 'k
that fresh fish, sufficient amount of salt (2% of the total weight of wet fish and starch), proper sequence of mixing of the 'keropok' mixture to form evenly-distributed fi
expansion, full gelatinisation of fish-starch gel, and elastic fish-starch gel formation. At high fish contents (60-70%) the formation of fish protein network in the matrix caused a drop in expansion. There was, however, a sharp increase in the compressive strength of the 'keropok' gel. This result is complemented by the higher storage modulus (G') and lower loss tangent ($\tan \delta$) values obtained. indicative of the existence of a strong elastic network. Such conditions were observed when the microstructure of the fish muscle fibres appeared to be well crosslinked.

The findings in this study revealed that in order to produce better expanded 'keropok' and a more elastic and fully gelatinised 'keropok' gel, superior in terms of appearance, shape and linear expansion, several important factors that ensure even distribution of fish proteins in the fish-starch gel must be taken into account. In conclusion, fresh fish, sufficient amount of salt (2% of the weight of wet fish and starch) and the proper sequence of adding ingredients in mixing are recommended to produce high quality 'keropok'.



Abstrak disertasi yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah.

**KESAN PROTEIN IKAN, GARAM, GULA DAN MONOSODIUM
GLUTAMAT TERHADAP SIFAT-SIFAT STRUKTUR MIKRO, REOLOGI,
FIZIKO-KIMIA KEROPOK IKAN**

Oleh

CHEOW CHONG SENG

Julai 1998

Pengerusi : Professor Yu Swee Yean, Ph. D.

Fakulti : Sains Makanan dan Bioteknologi.

Keropok merupakan makanan snek yang digemari ramai di kalangan negara-negara di rantau ASEAN. Kajian-kajian penyemperitan yang sering digunakan sebagai kajian perbandingan mungkin tidak menggambarkan sistem keropok yang sebenarnya. Ini menunjukkan betapa pentingnya penyelidikan ini yang melibatkan kajian terhadap faktor-faktor yang mempengaruhi kualiti keropok seperti protein ikan, garam, gula, monosodium glutamat (MSG) serta kesannya terhadap penggelatinan kanji ubi kayu dan sagu. Pemerhatian terhadap mikrostruktur keropok semasa pelbagai peringkat pemprosesan telah dilakukan dan dikaitkan dengan sifat reologinya.



Keputusan yang diperoleh menggunakan kalorimetri pengimbasan perbezaan (DSC) menunjukkan bahawa apabila kandungan protein ikan di dalam adunan meningkat, suhu akhir penggelatinan campuran tetap malar secara relatif manakala julat suhu penggelatinan menurun. Penambahan 1% gula dan 0.4% MSG tidak memberi kesan terhadap permulaan penggelatinan dan suhu puncak penggelatinan kanji sagu dan kanji ubi kayu. Penambahan 2% garam ke dalam adunan menghasilkan kesan yang paling ketara terhadap suhu penggelatinan, pengembangan linear apabila keropok digoreng serta perubahan bentuk kecil dan besar keropok. Teknologi penghasilan keropok kembang yang baik didapati sama dengan teknologi yang digunakan untuk surimi. Hasil keputusan mikroskop cahaya pula menunjukkan bahawa ikan yang segar, kandungan garam yang mencukupi (2% daripada jumlah berat ikan basah dan kanji) serta urutan pencampuran bahan adunan keropok yang betul akan membentuk jaringan serabut otot ikan yang seragam di dalam rangkaian gel kanji. Ini akan memastikan keropok yang dihasilkan akan kembang dengan baik, penggelatinan sepenuhnya gel kanji-ikan serta pembentukan gel kanji-ikan yang anjal. Pembentukan rangkaian protein ikan di dalam matriks kanji pada kandungan ikan yang tinggi (60-70%) menyebabkan keropok tidak berkembang dengan baik. Walaubagaimanapun kekuatan mampatan gel keropok meningkat. Keputusan ini disokong oleh data reologi nilai modulus storan (G') yang lebih tinggi serta nilai tangen kehilangan ($\tan \delta$) yang lebih rendah, menunjukkan pembentukan



satu sistem jaringan yang anjal dan kuat di dalam adonan tersebut. Keadaan begini dapat dilihat bila serabut otot ikan membentuk jalinan yang kuat dan teratur.

Hasil penyelidikan ini menunjukkan bahawa untuk menghasilkan keropok yang lebih kembang, gel keropok yang lebih anjal dan digelatinasikan sepenuhnya serta mempunyai ciri-ciri yang baik dari segi rupa, bentuk dan pengembangan linear, beberapa faktor penting yang memastikan pembentukan protein ikan yang seragam di dalam sistem gel kanji-ikan harus diberi perhatian. Kesimpulannya, penggunaan ikan segar, amaun garam yang mencukupi (2% daripada jumlah berat ikan basah dan kanji) serta urutan pencampuran bahan adonan keropok yang betul adalah disarankan untuk menghasilkan keropok berkualiti tinggi.

CHAPTER 1

GENERAL INTRODUCTION

Fish cracker, more commonly known as 'keropok' in Malaysia, is a popular snack food among countries in the ASEAN region. In the West, it is classified as 'half-product', 'intermediates' or 'third generation snack'. Basically, 'keropok' is prepared by forming a dough from a mixture of tapioca and/or sago starches, comminuted fish, salt, sugar, monosodium glutamate and water. The dough is then shaped, boiled or steamed to gelatinise the starch and cut into thin slices prior to sun drying. When immersed in hot oil, the product expands resulting in a low density, crispy snack food.

Fish 'keropok' is defined as the fish product made from fish and starch under the Malaysian Food Act 1983 and Food Regulation 1985 (Malaysia, 1985). Fish 'keropok' made of fresh fish, other than crustaceans and molluscs, shall contain not less than 20 per cent of protein, and the 'keropok' made of molluscs shall contain not less than 6.9% protein. It may contain permitted colouring substances and permitted flavour enhancers. The protein content of

