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**THE SYSTEMATIC DEVELOPMENT OF
A CONTROLLED FERMENTATION PROCESS
USING MIXED BACTERIAL STARTER CULTURES
FOR NHAM, A THAI SEMI-DRY SAUSAGE**

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ABSTRACT

The aim of this thesis was to improve the quality of Nham, a traditional Thai fermented sausage, using systematic product development techniques. The traditional Nham fermentation depends upon a random bacterial flora. This study identified the starter cultures which could be used and developed an industrial production method using mixed starter cultures.

Systematic experimental designs were used to guide the development of the Nham fermentation; identification of the important processing factors using a Plackett and Burman experimental design, formulation and process development using full factorial designs in sequence of 2^4 , 2^3 and 2^2 , and then a storage test of the product, testing of formulation and process in Thailand and finally a production trial of the new process in a factory in Thailand. Chemical, physical, microbiological, and sensory evaluation were used during the systematic product development. The study ended with consumer testing of the prototype product in the target market in Chiang Mai city and two villages - Ban Don Chai and Ban Ma-Kran.

The important factors affecting Nham quality were the mixed starter cultures and the carbon sources used in the Nham formulation. When the Nham base was inoculated with Lactobacillus plantarum 10^3 cfu.g⁻¹, Pediococcus cerevisiae 10^6 cfu.g⁻¹ and Micrococcus varians 10^3 cfu.g⁻¹ acid production, firmness and colour development were optimum, the product was microbiologically safe and the sensory properties were acceptable to consumers. The addition of carbon sources increased acid development. 0.5% glucose and 6% cooked rice were optimum levels in the Nham formulation.

Temperature and relative humidity also affected the Nham fermentation. Temperature increased the rate of pH reduction, the firmness and colour development. High relative humidity decreased the weight loss. The Nham fermented at 30°C and 97% relative humidity had optimum acid production and sensory properties.

Nham is sold in Thailand between 20°C and 30°C, and at relative humidity as high as 97%. Experimental samples stored under similar conditions had a shelf life of 11 days and 9 days respectively. When the product was chilled at 10°C and 1°C, the shelf life was extended to 63 days and 103 days respectively. Enterobacteriaceae and Staphylococcus aureus counts fell during storage and no yeasts or moulds were observed. Off-flavour development controlled the shelf life.

Product profiles were determined for the Nham by Thai consumers and the ideal ratio method was used during the sensory product testing. A profile test using linear scaling with fixed ideal points was used for the trained sensory panels. The floating ideal point was used with consumer panels when the prototype product was close to ideal profile. Category scaling was used in the consumer testing of the final product. Sensory evaluation by one hundred and twelve families in Chiang Mai province indicated that appearance, texture, and flavour of Nham made with the mixed starter cultures were good.

The Nham successfully developed by using the systematic product development had a high quality in terms of consistency, microbiological safety and long shelf life and was also accepted by the target Thai consumers. The product could be produced in a simple plant with the existing equipment in fermented meat product factories in Thailand but there would need to be an increase in technology of culture preparation and controlled fermentation. The product could be sent from the cottage industry in the North to all provinces in Thailand, particularly to Bangkok, and also had a potential to be exported to overseas countries if chilled conditions were used.

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TABLE OF CONTENTS

ABSTRACT	ii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	vi
LIST OF TABLES	xiii
LIST OF FIGURES	xvi
LIST OF APPENDICES	xviii

CHAPTER

1	IMPROVEMENT OF THAI FERMENTED MEAT PRODUCTS	1
1.1	INTRODUCTION	1
1.2	FERMENTED MEAT SAUSAGES IN THAILAND	1
1.3	NHAM PRODUCTION	3
1.4	MARKETING ASPECTS OF NHAM	3
1.5	NHAM FERMENTATION	5
1.6	RESEARCH ON NHAM FERMENTATION	5
1.7	USE OF MIXED STARTER CULTURES IN MEAT PRODUCTS	8
1.8	AN APPROACH TO NHAM DEVELOPMENT	12
1.8.1	Experimental Designs in Product Development	13
1.8.2	Sensory Testing in Product Development	14
1.9	AIM OF THE PROJECT AND PROJECT PLAN	15
2	PROJECT METHODS	17
2.1	SOURCES OF MATERIALS	17
2.1.1	Meat System	17
2.1.2	Curing Agents	17
2.1.3	Seasonings	17
2.1.4	Carbon sources	18
2.1.5	Starter cultures	18
2.1.6	Sausage Casings	18
2.2	PREPARATION OF CULTURES	18
2.3	METHOD OF NHAM PROCESSING	19
2.4	TESTING METHODS	21
2.4.1	Physical Tests	21
2.4.1.1	Sampling for Testing	21
2.4.1.2	Instron Compression, Shear Force and Energy	21

2.4.1.3	Reflective Colour	22
2.4.1.4	Gas Formation	22
2.4.1.5	Water Activity	23
2.4.1.6	Weight Loss	23
2.4.2	Chemical Tests	23
2.4.2.1	pH, Total Acidity, Volatile Acidity	23
2.4.2.2	Residual Nitrite	23
2.4.2.3	Reducing Sugars and Cooked Rice	23
2.4.3	Microbiological Tests	24
2.4.3.1	Method of Sampling and Preparation of Sample	24
2.4.3.2	Mesophilic Aerobic Microorganisms	24
2.4.3.3	Enterobacteriaceae	24
2.4.3.4	<u>Staphylococcus aureus</u>	25
2.4.3.5	Yeasts and Moulds	25
2.4.3.6	Starter Cultures	25
2.4.4	Sensory Tests	26
2.4.4.1	Testing Environment and Methods	26
2.4.4.2	Identification of Nham Characteristics and Selection of the Important Characteristics	27
2.4.4.3	Development of Scaling Method	30
2.4.4.4	Setting the Ideal Profile	32
2.4.4.5	Sensory Panel Selection	33
2.4.4.6	Training of the Sensory Panel	33
2.4.4.7	Sensory Panel in Thailand	33
3	IDENTIFYING THE IMPORTANT FACTORS AFFECTING THE CHARACTERISTICS OF NHAM	34
3.1	INTRODUCTION	34
3.2	PLACKETT-BURMAN DESIGN	34
3.3	STARTER PRODUCTION	37
3.4	SAUSAGE PREPARATION FOR PLACKETT-BURMAN DESIGN	39
3.5	TEST METHODS	41
3.6	RESULTS: CHEMICAL, MICROBIOLOGICAL, AND PHYSICAL CHARACTERISTICS OF NHAM	41
3.7	DISCUSSION	44
3.7.1	Starter Cultures Affecting the Characteristics of Nham	44
3.7.2	Ingredients Affecting the Characteristics of Nham	46

3.8	CONCLUSION	49
4	EFFECTS OF MIXED STARTER CULTURES ON THE CHARACTERISTICS OF NHAM	51
4.1	INTRODUCTION	51
4.2	EXPERIMENTAL DESIGN	51
4.3	SAUSAGE PREPARATION FOR 2 ⁴ FACTORIAL DESIGN	54
4.4	TEST METHODS	54
4.5	ANALYSIS OF RESULTS	55
	4.5.1 Empirical Equations Relating Dependent and Independent Variables	55
	4.5.2 Decoded Models	56
	4.5.3 Analysis of Variance	56
4.6	RESULTS	56
	4.6.1 Sensory Evaluation of Nham	56
	4.6.1.1 Overall Acceptability of Nham	56
	4.6.1.2 Correlation of Overall Acceptability with All Sensory Attributes	57
	4.6.1.3 Relationship between Overall Acceptability and the Starter Cultures	58
	4.6.2 Bacteriology	62
	4.6.3 pH Change During Fermentation	63
	4.6.4 Gas Production During Fermentation	65
	4.6.5 Firmness Development During Fermentation	66
	4.6.6 Colour Development During Fermentation	68
	4.6.7 Inhibition of Enterobacteriaceae	70
	4.6.8 Weight Loss During Fermentation	71
4.7	DISCUSSION	73
	4.7.1 Effects of Starter Cultures	73
	4.7.2 Selection of Inoculum Levels for Future Experiments	75
	4.7.3 Fermentation Time	75
4.8	CONCLUSION	75
5	EFFECTS OF CARBON SOURCES AND <u>L. PLANTARUM</u> ON THE pH REDUCTION IN NHAM	77
5.1	INTRODUCTION	77
5.2	EXPERIMENTAL DESIGN	77
5.3	SAUSAGE PREPARATION, TESTING AND ANALYSIS FOR 2 ³ FACTORIAL DESIGN	78

5.4	RESULTS	79
5.4.1	Chemical and Physical Changes During the First 48 Hours and their Relation to the Nham Quality	79
5.4.2	The Empirical Models of Dependent Variables During the First 48 Hours of Fermentation	83
5.4.3	Chemical and Physical Changes During 2-7 Days of Fermentation and their Relation to the Nham Quality	87
5.4.4	Sensory Evaluation of Nham	91
5.5	DISCUSSION	92
5.5.1	Chemical and Physical Changes	92
5.5.2	Acceptability of Nham	96
5.6	CONCLUSION	97
6	EFFECTS OF TEMPERATURE AND RELATIVE HUMIDITY ON THE RATE OF NHAM FERMENTATION	98
6.1	INTRODUCTION	98
6.2	EXPERIMENTAL DESIGN	98
6.3	SAUSAGE PREPARATION, TESTING AND ANALYSIS FOR 2 ² FACTORIAL DESIGN	99
6.4	KINETICS OF NHAM FERMENTATION	100
6.5	RESULTS	101
6.5.1	pH Change During Fermentation	101
6.5.2	Weight Loss During Fermentation	103
6.5.3	Firmness Development During Fermentation	104
6.5.4	Colour Development During Fermentation	106
6.5.5	Bacterial Studies	109
6.5.6	Sensory Evaluation	110
6.6	DISCUSSION	114
6.6.1	Effects of Temperature and Relative Humidity	114
6.6.2	Kinetics of Nham Fermentation	116
6.7	CONCLUSION	117
7	STORAGE TEST ON NHAM	119
7.1	INTRODUCTION	119
7.2	EXPERIMENTAL DESIGN	119
7.3	SAUSAGE PREPARATION, TESTING AND ANALYSIS FOR STORAGE TEST	119

7.4	DETERMINATION OF THE RATE OF DETERIORATION OF NHAM DURING STORAGE	120
7.5	RESULTS	121
7.5.1	Evaluation of Fermented Nham Before Storage	121
7.5.2	pH Change During Storage	122
7.5.3	Weight Loss During Storage	123
7.5.4	Firmness Change During Storage	123
7.5.5	Colour Change During Storage	124
7.5.6	Bacterial Studies During Storage	125
7.5.7	Sensory Evaluation During Storage	127
7.6	THE RATE OF DETERIORATION OF NHAM QUALITY DURING STORAGE	129
7.7	ESTIMATION OF SHELF LIFE OF NHAM	131
7.8	DISCUSSION	133
7.8.1	The Quality of Nham During Storage	133
7.8.2	Prediction of Nham Shelf-life	134
7.9	CONCLUSION	135
8	TESTING OF THE DEVELOPED NHAM IN THAILAND	136
8.1	INTRODUCTION	136
8.2	EXPERIMENTAL PLANNING	136
8.3	LABORATORY DEVELOPMENT	137
8.4	PRODUCTION TRIAL	137
8.5	CHEMICAL, PHYSICAL AND MICROBIOLOGICAL TESTING	138
8.6	SENSORY TESTING	138
8.6.1	Trained Sensory Panel	139
8.6.2	Consumer Panel	140
8.6.3	Consumer Test	140
8.6.3.1	The Sample	140
8.6.3.2	The Respondents	141
8.6.3.3	The Questionnaires	141
8.6.3.4	Organisation of the Test	142
8.6.3.5	Analyses of the Data	142
8.7	RESULTS OF NHAM PRODUCTION IN THAILAND	143
8.7.1	Comparison of Laboratory Fermentation with Fresh Pork in Thailand and Frozen Pork in New Zealand	143
8.7.2	Production Trial	144

8.8	RESULTS OF SENSORY TESTING	144
8.8.1	Comparison of Experimental and Commercial Nham	144
8.8.2	Consumer Panel Results	145
8.8.3	Comparison of Trained Sensory Panel and Consumer Panel Results	146
8.8.4	Consumer Product Test	148
8.8.4.1	Overall Results for Nham Characteristics and Acceptability	148
8.8.4.2	Acceptability of the Nham	149
8.8.4.3	Correlation of Acceptability with Selected Attributes	151
8.9	COMPARISON OF SENSORY TESTING RESULTS	152
8.9.1	Comparison of Ideal Profiles from the Trained and Consumer Panels	152
8.9.2	Comparison of Ideals from the Same Panel Using Different Test Products	153
8.9.3	Comparison of Ideal Ratio Scores from Consumer Panel and the Consumer Test	153
8.10	CONSUMER SURVEY ON BUYING NHAM	154
8.10.1	Eating Pattern for Nham	154
8.10.2	Criteria for Nham Buying Choice	155
8.10.3	Packaging Preference for Nham	156
8.10.4	Predicted Keeping Quality of Nham	158
8.10.5	Buying Prediction for Experimental Nham	158
8.11	DISCUSSION	160
8.11.1	Comparison of Proposed Production Method with the Present Commercial Methods	160
8.11.2	Possible Marketing of New Nham Against the Present Commercial Products	161
8.11.3	Use of Trained Panel, Consumer Panel and Consumer Test	162
8.12	CONCLUSION	163
9	DISCUSSION AND CONCLUSION	164
9.1	INTRODUCTION	164
9.2	USE OF EXPERIMENTAL DESIGNS IN NHAM DEVELOPMENT	164

9.3	USEFULNESS OF CONSUMER INPUTS AND SENSORY EVALUATION	167
9.4	THE FORMULATION AND PROCESS DEVELOPMENT	170
9.4.1	The Necessity of Using Starter Cultures in Nham	174
9.4.2	Effect of Starter Cultures on Characteristics of Nham	174
9.4.3	Change in Carbon Sources During Fermentation	178
9.4.4	Effects of Frozen and Fresh Meat	179
9.5	THE SHELF LIFE OF NHAM	179
9.6	SUBJECTIVE TESTS AND OBJECTIVE TESTS	180
9.7	RECOMMENDATION FOR FUTURE WORK	181
9.8	CONCLUSION	182
	REFERENCES	183
	APPENDICES	202

LIST OF TABLES

1.1	General growth characteristics of food poisoning bacteria and moulds relevant to the processing of fermented meat	9
1.2	Staphylococcal enterotoxin development, dry sausage, 22-24°C	10
1.3	Botulinal toxin development, summer style sausage at 27°C	11
2.1	Basic formulation for Nham production	20
2.2	Definitions to describe the important characteristics of Nham	29
3.1	Plackett-Burman matrix for determining the effects of 10 variables at two level using 16 runs	36
3.2	The numbers of starter cultures in different media after incubation at 30°C	38
3.3	Nham formulation in Plackett-Burman experiment	40
3.4	The chemical and microbiological characteristics after 60 hours of Nham fermentation at 30°C and 43% relative humidity	42
3.5	The physical characteristics after 60 hours of Nham fermentation at 30°C and 43% relative humidity	43
3.6	The main effects and significance levels of starter cultures on the characteristics of Nham	45
3.7	The main effects and significance levels of curing agents on the characteristics of Nham	47
3.8	The main effects and significance levels of carbohydrate and seasonings on the characteristics of Nham	49
4.1	The full 2 ⁴ factorial experiment with blocks, including four centrepoints for investigating the effects of mixed starter cultures on the characteristics of Nham	53
4.2	The mean ideal ratio scores of overall acceptability during 3-14 days of fermentation affected by starter cultures	57
4.3	Correlations of overall acceptability with the sensory attributes of Nham during 3-14 days fermentation	58
4.4	Fitted models for overall acceptability during 3-14 days of fermentation affected by starter cultures	59
4.5	Analysis of variance of overall acceptability during fermentation affected by starter cultures	60
4.6	Fitted models for pH during 3-14 days of fermentation affected by starter cultures	64
4.7	Fitted models for the gas production (G) during 2-6 days of fermentation affected by starter cultures	66

4.8	Fitted models for the compression force (CF) and compression energy (CE) during 3-10 days of fermentation affected by starter cultures	68
4.9	Fitted models for tristimulus values (X Y Z) and residual nitrite (RN) during 1-10 days of fermentation affected by starter cultures	70
4.10	Fitted models for weight loss (WL) during 7-14 days of fermentation affected by starter cultures	72
5.1	2 ³ factorial design for investigating the effects of carbon sources and <u>L. plantarum</u> on the pH reduction in Nham	78
5.2	Cooked rice, reducing sugars and pH at 18 hours of fermentation	81
5.3	The weight loss and compression force at 24 and 48 hours of fermentation	82
5.4	The tristimulus values (X Y Z) at 24 and 48 hours of fermentation	83
5.5	Fitted models for the reducing sugars (RS) during 6-24 hours of fermentation affected by carbon sources and <u>L. plantarum</u>	84
5.6	Fitted models for the residual level of cooked rice (CR) during 12-48 hours of fermentation affected by carbon sources and <u>L. plantarum</u>	85
5.7	Fitted models for the compression force (CF) during 24-48 hours of fermentation affected by carbon sources and <u>L. plantarum</u>	86
5.8	Fitted models for the tristimulus values (X Y Z) during 24-48 hours of fermentation affected by carbon sources and <u>L. plantarum</u>	86
5.9	The overall acceptability mean ideal ratio scores of Nham fermented for 3 and 7 days	91
6.1	The 2 ² factorial design with centrepoin ts for investigating the effects of temperature and relative humidity on the rate of Nham fermentation	99
6.2	Fitted models for pH during 18-72 hours of fermentation affected by temperature	102
6.3	Calculation of the rate of pH reduction in Nham at different temperatures	102
6.4	Fitted models for weight loss (WL) during 72 hours of fermentation affected by temperature and relative humidity	104
6.5	Fitted models for the effect of temperature on the compression force (CF) during 72 hours of fermentation	105
6.6	Fitted models for the tristimulus values (X Y Z) at 48-72 hours of fermentation affected by temperature	108
6.7	The bacterial numbers in Nham fermented 1 and 3 days at different temperatures and relative humidities	109
6.8	The mean ideal ratio scores of most important attributes and overall acceptability of Nham fermented at different temperatures and relative humidities	111

6.9	Fitted models for the Nham characteristics (sensory evaluation) fermented at different temperatures for 3 days	111
6.10	Correlations between subjective and objective tests on Nham fermented at 3 days	113
6.11	The significant correlations between pH and compression force and tristimulus values of Nham fermented for up to 3 days	114
7.1	Prediction the shelf life of Nham (days) based on overall acceptability and off-flavour	133
8.1	Comparison of Nham produced in the laboratory (using fresh or frozen meat) in terms of pH, weight loss and bacterial counts	143
8.2	Comparison between experimental and commercial Nham (brand A and brand B). Ratios analysed using logarithms of ideal ratio scores	145
8.3	The mean ideal ratio scores of Nham fermented 2 days at 30°C, 97% RH for each attribute	146
8.4	Comparison of trained sensory panel and consumer panel using raw ideal ratio scores and logarithms of ideal ratio scores	147
8.5	Nham characteristics and acceptability in consumer product test	148
8.6	Acceptability of experimental Nham in consumer product test by location, sex, age group and career	150
8.7	Correlation of selected attributes of Nham with overall acceptability using the data from consumer product test	151
8.8	Mean ideal scores of Nham for the trained panel at Massey University, trained panel at Chiang Mai University and consumer panel in Thailand	152
8.9	Mean ideal scores of two commercial Nham (brand A and brand B) and experimental Nham (X) by trained panel in Chiang Mai	153
8.10	Comparison of the ideal ratios for the consumer panel and consumer test of selected attributes	154
8.11	Eating pattern for Nham	155
8.12	Major influences on buying decisions and retail outlets	156
8.13	Packaging preferences for Nham	157
8.14	Storage and keeping quality of Nham	158
8.15	Buying prediction for experimental Nham	159
9.1	Experimental designs, stages, and objectives during the formulation and process development	166
9.2	Types of sensory panels and evaluation techniques used in the project	168
9.3	Final formulation of Nham	172

LIST OF FIGURES

2.1	A Nham characteristics identification questionnaire	28
2.2	Nham characteristics and ideal point questionnaire	31
2.3	Standard questionnaire for Nham sensory testing	32
4.1	Ideal ratio profile of Nham added <u>P. cerevisiae</u> at the high level with the low levels of the other cultures tested by trained panel	61
4.2	The numbers of <u>L. plantarum</u> ; <u>L. brevis</u> ; <u>P. cerevisiae</u> and <u>M. varians</u> during 14 days of fermentation using combinations of the four cultures	62
4.3	pH values during 14 days of fermentation using combinations of four cultures - <u>M. varians</u> , <u>P. cerevisiae</u> , <u>L. plantarum</u> and <u>L. brevis</u>	63
4.4	The relationship between overall acceptability ideal ratio score and pH of Nham product	64
4.5	Gas formation during 14 days of fermentation using combinations of four cultures - <u>M. varians</u> , <u>P. cerevisiae</u> , <u>L. plantarum</u> and <u>L. brevis</u>	65
4.6	Compression force and compression energy during 14 days of fermentation using combinations of four cultures - <u>M. varians</u> , <u>P. cerevisiae</u> , <u>L. plantarum</u> and <u>L. brevis</u>	67
4.7	Tristimulus values (X Y Z) and residual nitrite during 14 days of fermentation using combinations of four cultures - <u>M. varians</u> , <u>P. cerevisiae</u> , <u>L. plantarum</u> and <u>L. brevis</u>	69
4.8	The numbers of Enterobacteriaceae during 14 days of fermentation using combinations of four cultures - <u>M. varians</u> , <u>P. cerevisiae</u> , <u>L. plantarum</u> and <u>L. brevis</u>	71
4.9	Weight loss during 14 days of fermentation using combinations of four cultures - <u>M. varians</u> , <u>P. cerevisiae</u> , <u>L. plantarum</u> and <u>L. brevis</u>	72
5.1	Cooked rice, reducing sugars, and pH during the first 48 hours of fermentation affected by the concentrations of cooked rice, glucose and <u>L. plantarum</u>	80
5.2	Cooked rice, reducing sugars, and pH during the 1-2 days (I) and 2-7 days (II) of fermentation affected by the concentrations of cooked rice, glucose and <u>L. plantarum</u>	88
5.3	Weight loss during 1-2 days (I) and 2-7 days (II) of fermentation affected by the concentrations of cooked rice, glucose and <u>L. plantarum</u>	89
5.4	Compression force during 1-2 days (I) and 2-7 days (II) of fermentation affected by the concentrations of cooked rice, glucose and <u>L. plantarum</u>	89

5.5	Tristimulus values (X Y Z) during 1-2 days (I) and 2-7 days (II) of fermentation affected by the concentrations of cooked rice, glucose and <u>L. plantarum</u>	90
5.6	The chemical and physical changes during the first 48 hours and 2-7 days of fermentation affected by carbon sources and <u>L. plantarum</u>	93
6.1	pH change during 72 hours fermentation at different temperatures and relative humidities	101
6.2	The rate of pH reduction during fermentation at 20°C, 25°C and 30°C	103
6.3	Weight loss during 72 hours fermentation at different temperatures and relative humidities	103
6.4	Compression force during 72 hours fermentation at different temperatures and relative humidities	104
6.5	The rate of firmness development during fermentation at 20°C, 25°C and 30°C	105
6.6	Tristimulus values (X Y Z) during 72 hours fermentation at different temperatures and relative humidities	107
6.7	The rate of colour development (x-value) during fermentation at 20°C, 25°C and 30°C	109
7.1	pH change during storage at different temperatures (1-30°C)	122
7.2	Weight loss during storage at different temperatures (1-30°C)	123
7.3	Compression force during the storage at different temperatures (1-30°C)	124
7.4	Tristimulus values (X Y Z) during storage at different temperatures (1-30°C)	125
7.5	Starter cultures (<u>L. plantarum</u> , <u>P. cerevisiae</u> and <u>M. varians</u>) and mesophilic aerobic counts during storage at different temperatures (1-30°C)	126
7.6	Pathogenic bacteria (Enterobacteriaceae and <u>S. aureus</u>) during storage at different temperatures (1-30°C)	127
7.7 (a)	Sensory attributes (firmness, colour, sourness and off-flavour) during storage at different temperatures (1-30°C)	128
(b)	Overall acceptability during storage at different temperatures (1-30°C)	128
7.8	The rate of pH change; weight loss; firmness; and colour deterioration during storage at different temperatures (1-30°C)	130
7.9	The rate of off-flavour; and overall acceptability changes during storage at 1-30°C	132
9.1	Systematic product development system and experimental designs used for improvement of Nham quality	165
9.2	Process chart of Nham production using mixed starter cultures	173
9.3	Effect of mixed starter cultures on Nham system	176

LIST OF APPENDICES

2.1	The calculation of compression and shear energy	202
2.2	The gas formation calculation	203
2.3	Standard curve of residual nitrite	204
2.4	Reducing sugars and cooked rice determination	205
2.5	Standard curve for reducing sugars as glucose	206
2.6	The important attributes of Nham identified by panelists	207
2.7	Formulation of Nham for first trained panel to identify and discuss Nham characteristics	208
2.8	The questionnaire and definitions used to train the panelists in Thailand	209
4.1	Trained panel for Nham testing, Nham characteristics	211
4.2	Results for 2 ⁴ factorial design used for multiple regression	212
4.3	Regression equation and regression statistics from the 2 ⁴ factorial design and an example of the method used to test for goodness of fit	225
4.4	The multiple regression equations for dependent variables affected by starter cultures	226
4.5	Analysis of variance of overall acceptability during Nham fermentation	236
5.1	Results for 2 ³ factorial design used for multiple regression	238
5.2	The multiple regression equations for dependent variables affected by carbon sources and <u>L. plantarum</u>	243
6.1	Results of 2 ² factorial design for multiple regression	246
6.2	The multiple regression equations for dependent variables affected by temperature and relative humidity	248
6.3	Calculations of the rate of firmness and colour development in Nham incubated at different temperatures	250
7.1	The storage test questionnaire	251
7.2	The results of dependent variables during the storage of Nham at different temperatures (1-30°C)	252
7.3	The rate of pH, weight loss, firmness, colour, off-flavour, and overall acceptability changes during storage of Nham at different temperatures (1-30°C)	257
7.4	Calculation of the shelf life of Nham at different temperatures (1-30°C)	259
8.1	Product testing questionnaire (translated into Thai)	260
8.2	Questionnaire for housewives (translated into Thai)	262
8.3 (a)	Product testing questionnaire (translated into English)	265
(b)	Questionnaire for housewives (translated into English)	267
8.4	The overall acceptability of developed Nham	269

8.5 (a) Eating pattern for Nham	271
(b) Criteria for Nham buying choice	272
(c) Packaging preference for Nham	273
(d) Predicted keeping quality of Nham	275
(e) Buying prediction for experimental Nham	276

EXPERIMENTAL NHAM, THAI SEMI-DRY SAUSAGE

