

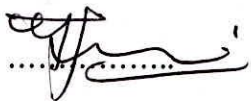
**SELECTION OF RICE VARIETIES SUITABLE FOR RICE
BASED FOOD PRODUCTS**

By

Mohamed Jaleel Mohamed Fari

Thesis submitted to the University of Sri Jayewardenepura
for the award of the
Degree of Master of Philosophy in Food Science and Technology
on
September 2009.

The work described in this thesis was carried out by me under the supervision of Mrs. Damitha Rajapaksa and Prof. K.K.D.S Ranaweera and a report on this has not been submitted in whole or in part to any University or any other institution for another Degree/Diploma.



M.J.M. Fari



Date

We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.

D. Rajapaksa

Mrs. Damitha Rajapaksa


.....

Prof. K.K.D.S. Ranaweera

Prof. K.K.D.S. Ranaweera
Head/Department of Food Science and Technology,
Faculty of Applied Sciences,
University of Sri Jayewardenepura,
Gangodawila,
Nugegoda, Sri Lanka.

We certify that the candidate has incorporated all corrections, additions and amendments recommended by the examiner.

D. Rajapaksa

Mrs. Damitha Rajapaksa

Prof. K.K.D.S. Ranaweera

Prof. K.K.D.S. Ranaweera

Prof. K.K.D.S. Ranaweera
Head/Department of Food Science and Technology,
Faculty of Applied Sciences,
University of Sri Jayewardenepura,
Gangodawila,
Nugegoda, Sri Lanka.



TABLE OF CONTENTS

TABLE OF CONTENTS.....	i
LIST OF TABLES.....	vii
LIST OF FIGURE	ix
ABBREVIATION	xi
ACKNOWLEDGEMENT	xiii
ABSTRACT.....	xv
1.0 INTRODUCTION	1
2.0 LITERATURE REVIEW	7
2.1 Rice overview.....	7
2.2 Structure of rice grain	7
2.2.1 Hull	8
2.2.3 Caryopsis coat.....	9
2.2.4 Aleurone layer.....	9
2.2.5 Embryo.....	9
2.2.6 Endosperm	10
2.2.7 Milling fraction	10
2.3 Rice composition	11
2.3.1 Starch	12
2.3.1.1 Amylose.....	12
2.3.1.2 Amylopectin.....	13
2.3.2 Rice lipids	14
2.3.3 Rice protein.....	14
2.4 Functional properties of rice.....	15
2.4.1 Starch gelatinization.....	15
2.4.2 Retrogradation or setback	16
2.4.3 Pasting behaviour.....	16
2.5 Thermal properties of rice	17
2.5.1 Glass transition temperature	18

2.5.2 Gelatinization temperature.....	18
2.5.3 Amylose-lipid complex melting	19
2.5.4 Amylopectin staling.....	19
2.5.5 Freeze thaw stability	19
2.5.6 Staled amylose melting.....	20
2.6 Rice varieties in Sri Lanka.....	20
2.7 Rice Based Food Products.....	22
2.7 Bread	23
2.7.1 Rice bread	24
2.7.1.1 Previous studies on rice bread.....	27
2.7.1.2 Rice bread with gluten	28
2.7.1.3 Rice bread with hydrocolloids	28
2.7.1.4 Varietal influence on rice bread.....	30
2.8 Rice noodles (Vermicelli).....	31
2.8.1 Processing of rice noodles	31
2.8.1.1 Wet milled rice noodles	31
2.8.1.2 Dry milled rice noodles.....	32
2.8.1.2.1 Pre gelatinized flour.....	33
2.8.2 Varietal influence on rice noodles	34
2.9 Extrusion Cooking	36
2.9.1 Advantages of extrusion technology.....	36
2.9.2 Types of Extruders.....	37
2.9.2.1 Single screw extruder.....	37
2.9.2.2 Twin screw extruders.....	38
2.9.2.2.1 Counter rotating twin screw extruder	39
2.9.2.2.2 Co rotating twin screw extruder.....	39
2.9.3 Extrusion cooking of rice.....	39
2.9.3 Changes during extrusion cooking.....	40
2.9.3.1 Effect of extrusion on starch	40
3.0 METHODOLOGY	43

3.1 Materials	43
3.2 Preparation of sample	43
3.3 Physicochemical analysis of rice	44
3.3.1 Moisture content	44
3.3.2 Crude protein content.....	44
3.3.3 Crude fat content.....	44
3.3.4 Amylose content	44
3.3.5 Gel consistency	45
3.3.6 Gelatinization Temperature (GT)	45
3.3.6.1 Alkaline degradation test	45
3.3.7 Particle size analysis	46
3.3.8 Colour grade test.....	47
3.3.9 Pasting properties of rice	47
3.3.10 Starch properties	48
3.4 Rice noodles	49
3.4.1 Rice noodle preparation method	49
3.4.2 Cooking characteristics of rice noodles	52
3.4.2.1 Cooking time.....	52
3.4.2.2 Cooking loss or Total solids in gruel	52
3.4.2.3 Swelling ratio or rehydration	53
3.4.3 Textural characteristics of noodles	53
3.4.3.1 Tensile strength and extensibility	53
3.4.3.2 Firmness and elastic recovery of noodles	53
3.4.4 Sensory evaluation of rice noodles	54
3.5 Preparation of rice bread	54
3.5.1 Physical dough properties of dough.....	54
3.5.2 Dough extensible properties	55
3.5.3 Preparation of bread.....	56
3.5.3.1 Preliminary test	56
3.5.3.2 Bread with different rice varieties	56

3.5.4 Bread weight and volume	58
3.5.5 Bread firmness	60
3.5.6 Sensory analysis of bread.....	60
3.6 Rice extruded products.....	61
3.6.1 Sample preparation	61
3.6.2 Twin screw extruder	61
3.6.3 Extrusion cooking	64
3.6.4 Physicochemical analysis.....	64
3.6.4.1 Cross section expansion (CE, %)	64
3.6.4.2 Longitudinal expansion (LE, cm/g)	64
3.6.4.3 Bulk density	65
3.6.4.4 Water Solubility Index (WSI), Water absorption index (WAI)	65
3.6.4.5 Fat absorption index (FAI).....	66
3.6.4.6 Shear Strength or Hardness.....	66
3.6.4.7 Microstructure.....	67
3.7 Statistical analysis	67
4.0 RESULTS AND DISCUSSION	68
4.1 Physicochemical properties of rice	68
4.1.1 Moisture content of rice	68
4.1.2 Protein content	68
4.1.3 Fat content.....	69
4.1.4 Amylose content in rice	70
4.1.5 Gel consistency	71
4.1.6 Gelatinization Temperature (GT)	73
4.1.7 Pasting properties of rice	75
4.1.8 Starch properties	77
4.1.9 Particle size of rice flour.....	79
4.1.10 Colour of rice	80
4.2 Preparation of rice noodles	82
4.2.1 Rice noodles from different rice varieties.....	82

4.2.2	Cooking quality of rice noodles	83
4.2.3	Textural properties of rice noodles	85
4.2.4	Sensory attributes of rice noodles	87
4.2.5	Relationship between physicochemical properties of rice and noodle quality characteristics.....	89
4.3	Preparation of rice bread	92
4.3.1	Dough rheological properties of composite mixture with 30% of rice flour	92
4.3.1.1	Water absorption capacity.....	92
4.3.1.2	Dough development time.....	93
4.3.1.3	Stability.....	94
4.3.1.4	Time of breakdown	95
4.3.1.5	Tolerance index.....	95
4.3.2	Extensograph measurements of composite flour mixture with 30% rice flour ...	95
4.3.2.1	Resistant to extension (F).....	96
4.3.2.2	Extensibility (L).....	97
4.3.2.3	Energy (E).....	97
4.3.2.4	Ratio between resistance to extension and extensibility (R)	98
4.3.2.5	Extensograph properties with different fermentation time	98
4.3.3	Properties of bread loaves prepared in the preliminary trial.....	100
4.3.4	Bread properties of composite flour mixture with 30% rice flour.....	100
4.3.4.1	Loaf weight (g)	101
4.3.4.2	Bread loaf volume (ml).....	102
4.3.4.3	Specific loaf volume (ml/g)	103
4.3.4.4	Firmness (N) of bread	104
4.3.5	Sensory characteristics of bread.....	104
4.3.5.1	Crust colour.....	105
4.3.5.2	Appearance	106
4.3.5.3	Crumb texture	106
4.3.5.4	Taste.....	107
4.3.5.5	Overall acceptability	107

4.3.6 Bread incorporated with different rice varieties	108
4.3.7 Relationship of physicochemical properties of rice and Farinograph properties with bread properties.....	108
4.4 Extrusion cooking of rice.....	111
4.4.1 Rice extrudates from different rice varieties.....	111
4.4.2 Properties of extrudates made from different rice varieties.....	112
4.2.2.1 Expansion of rice extrudates	112
4.2.2.2 Bulk Density of rice extrudates.....	113
4.2.2.3 Water Solubility Index (WSI) and Water absorption index (WAI) of rice extrudates	115
4.2.2.4 Fat absorption index (FAI) of rice extrudates.....	118
4.2.2.5 Shear strength.....	118
4.2.2.6 Microstructure.....	120
4.3.3 Relationship between physicochemical characteristics of and extruded properties.....	121
5.0 CONCLUSIONS	123
6.0 REFERENCES.....	125
7.0 APPENDICES	135
Appendix 1 - List of Publication & Communication.....	135
Appendix 2 - Detailed information on rice varieties studied.....	136
Appendix 3 - Sensory Evaluation of Rice Noodles	139
Appendix 4 - Sensory Evaluation of Bread	140
Appendix 5 - Schematic diagram of Amylograph	141
Appendix 6 - Farinograph obtained from different rice varieties incorporated at 30 % level dough.....	142

LIST OF TABLES

Table 2.1 Gross composition of rice fractions	11
Table 2.2 New improved rice varieties recommended by the Department of Agriculture, Sri Lanka	21
Table 2.3 Types of protein in wheat and rice (% of total protein)	25
Table 3.1 Description of alkali spreading value for milled rice, after soaking in 1.7 % KOH for 23 hours.	46
Table 3.2 The screw configuration of the twin-screw extruder	63
Table 4.1 Protein and fat content of rice	71
Table 4.2 Amylograph pasting properties of rice	75
Table 4.3 Starch properties of rice	78
Table 4.4 Particle size distribution of rice flour	80
Table 4.5 Chromameter indices for different rice varieties	81
Table 4.6 Textural characteristics of rice noodles	85
Table 4.7 Sensory attributes of rice noodles	87
Table 4.8 Correlation between physicochemical properties of rice varieties and noodle quality	89
Table 4.9 Physical dough properties of composite flour mixture with 30% rice flour	92
Table 4.10 Extensograph properties of dough after 45 minutes	96
Table 4.11 Properties of bread made with different proportion of rice flour	101
Table 4.12 Physical properties of rice bread	102
Table 4.13 Sensory characteristics of bread	105

Table 4.14 Correlation coefficient of physicochemical and dough properties with bread quality attributes	109
Table 4.15 Water Solubility Index (WSI) and Water absorption index (WAI) of rice extrudates	115
Table 4.16 Correlation between physicochemical properties of rice and extrudate properties	121

LIST OF FIGURE

Figure 1.1 Extent of paddy sown and harvested in Sri Lanka	2
Figure 1.2 Annual production (000' MT) and average yield (kg/Ha) of paddy in Sri Lanka	2
Figure 2.1 Longitudinal section of rice grain	8
Figure 2.2 Structure of amylose chain	13
Figure 2.3 Structure of amylopectin chain	13
Figure 2.4 Processed rice based products	22
Figure 3.1 Brabender Amylograph	48
Figure 3.2 Flow chart of rice noodles processing	50
Figure 3.3 Schematic diagrams of rice noodles processing	51
Figure 3.4 Flow chart of rice bread processing	57
Figure 3.5 Processing steps of rice bread	58
Figure 3.6 Longitudinal view of twin-screw extruder	62
Figure 3.7 Frontal view of extruder	62
Figure 4.1 Moisture content of rice	68
Figure 4.2 Amylose content in brown rice and polished rice	70
Figure 4.3 Gel length of rice and their corresponding GC classification	72
Figure 4.4 Alkali spreading value of rice in 1.7 % KOH and their corresponding GT classification	74
Figure 4.5 Rice noodles made from different rice varieties	82
Figure 4.6 Cooking quality of rice noodles	84

Figure 4.8 Extensibility of dough at different times of fermentation	99
Figure 4.9 Energy of dough at different times of fermentation	99
Figure 4.10 Ratio of dough at different times of fermentation	100
Figure 4.11 Firmness of rice bread	103
Figure 4.12 Bread prepared from 30% rice flour incorporated with different rice varieties	107
Figure 4.13 Rice extrudates from different rice varieties	110
Figure 4.14 Cross sectional expansion (CSE) and Longitudinal expansion (LE) of rice extrudates	112
Figure 4.15 Bulk densities of rice extrudates from different rice varieties	113
Figure 4.16 Fat absorption index of rice extrudates	118
Figure 4.17 Shear strength values of rice extrudates	119
Figure 4.17 Cell number per cross sectional area of extrudates	120

ABBREVIATION

°C – Degree Celsius

µm – micro meter

a* – red-green colour

AACC – American Association of Cereal Chemists

AC – Amylose content

AOAC – Association of Official Analytical Chemists

AP – Amylopectin

At – Ambalantota

b* - yellow-blue colour

Bg – Bathalagoda

BU – Brabender units

Bw – Bombuwala

CE - Cross-sectional expansion

CIE – International Commission on Illumination

CMC – carboxymethylcellulose

Da – Dalton

DDT - Dough development time

DOM - Degree of milling

DPn – Degree of polymerization

E – Energy

ER (%) – Elastic recovery

F – Resistant to extension

F (%) – Firmness
GC – Gel consistency
GO - glucose oxidase
GT – Gelatinization Temperature
HPMC – Hydroxypropyl methyl cellulose
HRW – Hard red winter
HTST – High temperature short temperature
IRRI – International Rice Research Institute
L – Extensibility
L* - Brightness
Ld – Labuduwa
LE – Longitudinal expansion
MC – Methylcellulose
OIA – Oil Absorption index
PS 50 – Median particle size
RMS – Raw Material Specification
RVA – Rapid Visco Analyzer
SLSI – Sri Lanka Standards Institution
SLV – Specific loaf volume
Tg – Glass transition temperature
Tm – Enthalpy of glass melting endotherm
WAI – Water absorption index
WSI – Water solubility Index

ACKNOWLEDGEMENT

I would like to express my heartfelt thanks to my supervisor Mrs. Damitha Rajapakse, Senior Research Officer, Food Technology Section, Industrial Technology Institute (ITI) for her invaluable advises, persistent and generous help and highly encouraging guidance extended to conduct this study. Her unhesitant help and co-operation at all times has contributed immensely to make this study a success.

I wish to express my sincere appreciation and gratitude to my supervisor, Prof. K.K.D.S. Ranaweera, Head, Department of Food Science & Technology, University of Sri Jayewardenapura, for his valuable advice, kind guidance and professional expertise throughout my study.

My deep sense of gratitude is expressed to Dr. (Ms.) Janaki Gooneratne, Head, Food Technology Section, Dr. (Ms.) Shanthi Wilson, Deputy Director – Research & Development, ITI, and Dr. A.M. Mubarak, Director, ITI for granting me the opportunity to carry out this study.

I am deeply grateful to Mrs. Theja Herath, SRO, Mr. Nuwan Ranaweera, RO, Mr. Tharaka Gunawardena, RO, and Mr. D.M. Weerawardena for supporting me with my work in many ways. The secretarial assistance of Mrs. Lilani Gunathilaka, Mrs. Prasadi Sapukotuna and Ms. Udari Weerasingha are gratefully acknowledged.

I also express my gratitude to Mrs. Karuna Aponso, TO, Mrs. R.K.P.N. Indunil TA, Mrs. Agnes Fernando, STO, Mrs. Shiranthi Perera, TO and all the staff members of Food Technology Section who helped in numerous ways during the period of this study.

I wish to acknowledge Dr. Amitha Benthota, Senior Research Officer and Dr. Gamini Dissanayaka, Director, Rice Research and Development Institute, Bathalagoda for providing me the rice samples and necessary information for my studies.

I extend my thanks to Dr. (Mrs.) Nandani Ediriweera, Consultant Food Technology, 2KR Project, Mrs. Dilamani Warnasuriya, Head, Information Technology Centre, ITI and Mrs. Purnima Jayasinhgea Information Technology Centre, ITI of for their fullest support during finalizing of the thesis. I extend my thanks to Mr. Gamini Deshapriya, Laboratory assistant for his kind help in various ways.

Also I wish to thank all the staff members of ITI who helped in many ways to furnish this study successfully specially the staff members of Information Service Centre, ITI.

Finally I extend my gratitude to my ever loving parents and wife, who all way behind me to bring this as success.

SELECTION OF RICE VARIETIES SUITABLE FOR RICE BASED FOOD PRODUCTS

M.J.M. Fari

ABSTRACT

Rice (*Oryza sativa* L.) is the staple food of Sri Lanka and achieved self sufficiency in rice production. Diversification of rice based product will enable the consumer to have a wide range of products. A wide range of rice varieties are being cultivated under different agro-climatic conditions in Sri Lanka. These different varieties having compositional differences, contribute to the diversity of physicochemical properties. A study was carried out to select the suitable rice varieties for manufacturing rice based food products such as bread, noodles and extrudates.

Popularly grown Sri Lankan rice varieties namely Bg 300, Bg 352, Bg 403, Bg 94-1, Ld 356, Bw 272-6b, At 405 and At 306 were used for the present study. Physicochemical properties of the rice varieties and the quality characteristics of rice noodles, rice bread and rice extrudates were investigated.

Physicochemical properties of rice had shown a wide variation among different rice varieties. Amylose content (AC) was high in polished rice than brown rice irrespective of the variety. AC of polished rice ranged from 21.49 ± 1.468 in At 405 to 36.93 ± 0.346 % in Bg 94-1. Amylograph pasting properties of rice varieties showed a significant ($p < 0.05$)

variation for all the pasting parameters. Protein content was ranged from 6.84 ± 0.199 in Bg 94-1 to 11.18 ± 0.219 in Ld 356.

Rice noodles were prepared by pre gelatinizing the dough followed by cold extrusion. Cooking loss of rice noodles was high in At 405 (19.17 ± 3.503 %), but it was low in Bg 403 (9.19 ± 0.327 %). Tensile strength of noodles was significantly ($p < 0.05$) high in Bg 352 (16.7 ± 3.37 g) whereas it was significantly ($p < 0.05$) low in At 405 (8.0 ± 1.72 g). Overall acceptability of rice noodles from At 405 had the significantly ($p < 0.05$) lowest score and rice noodles from Bg 300 had significantly ($p < 0.05$) higher value. AC had significant correlation with cooking loss, swelling ratio, tensile strength, extensibility and elastic recovery at $p < 0.05$.

Incorporation of different rice varieties at 30 % level into wheat flour had a significant ($p < 0.05$) variation in physical dough properties, physical bread properties and sensory attributes of bread. Rice variety Bg 352 incorporated bread had the significantly ($p < 0.05$) highest specific loaf volume (5.22 ± 0.108 g/ml) and lowest firmness (6.52 ± 0.299 N).

Rice extrudates were prepared in co-rotating, fully intermeshing twin screw extruders. Wide variation in extrudate properties were observed among rice varieties. Rice variety Bg 352 and Bg 300 had greater puffing during extrusion. Rice varieties from Bathalagoda exhibit low WSI and high WAI. AC significantly correlated negatively with density ($r = -0.365$, $p < 0.01$), WSI ($r = -0.522$, $p < 0.001$) and FAI ($r = -0.352$, $p < 0.05$) and positively with

WAI ($r=0.569$, $p<0.001$). Protein content had significant effect on WSI and WAI. Amylograph pasting properties also had a significant effect on rice extrudate properties.

The amylose content was the major factor affecting the quality characteristics of rice based products, even though the Amylograph pasting properties showed significant differences. Two wide grown rice varieties, namely Bg 300 and Bg 352 showed overall best performance for making rice noodles, rice bread and rice extrudates. Also other rice varieties, namely Bg 94-1, Bg 403 and At 403 also preferred in making such products.