

ACKNOWLEDGEMENTS

Praise and gratitude to God for His blessings in accomplished this thesis entitled “SOLID STATE FERMENTATION OF OKARA USING *Aspergillus oryzae*” that was written as partial fulfilment of the academic requirements to obtain *Sarjana Teknologi Pertanian Sastra Satu* Food Technology, Universitas Pelita Harapan.

There were many supports, prayers, guidance, and help received for the author from many parties. In this chance, the author would like to express gratitude and appreciation to those parties, including:

1. Eric Jobiliong, Ph. D., as Dean of Faculty Science and Technology
2. Sunie Rahardja, M. S. CE., as Vice Dean of Faculty Science and Technology
3. Laurence, S. T., M. T., as Director of Faculty Science and Technology.
4. Ir. W. Donald R. Pokatong, M.Sc., Ph.D., as Head of Food Technology Study Program UPH and Academic Supervisor, for the support until this thesis was completed.
5. Ratna Handayani, MP., as Vice Head of Food Technology Study Program UPH, for the support until this thesis was completed.
6. Dr.-Ing. Azis Boing Sitanggang, M.Sc., as Supervisor for the time, guidance, support, and motivation until this thesis was completed.
7. Wenny S.L. Br. Sinaga, M.Si., as Co-Supervisor for the time, guidance, support, and motivation until this thesis was completed.
9. Dr. Hardoko, as thesis defense examiner who give many useful advices for the thesis completion.
10. Yuniwaty Halim, M.Sc., as thesis defense examiner who give many useful advices for the thesis completion, and as the Head of Laboratories, where the author conducted the final project.
11. Dr. Adolf J. N. Parhusip, M.Si., Nuri Anugrahati, MP., and Tagor M. Siregar, M.Si., as the Head of Laboratories, where the author conducted the final project.

12. Virly, S.TP., Adhi, Yosafat Rudju, and Adzie, for helping the author at laboratories.
13. Father (Mechael Joe Putra), Mother (Evi Kim), and brother (Eric Fernando, and Jason Fernando), as beloved family for endless support, and prayers.
14. Felicia Wie as a partner for the endless support, and help.
15. Caryn Fidelia Miranda, Willy Williamdy, Antony Japutra, Handy Gosun, and Brian Widjaja as partners in the same team for support, and help
16. Jeslyn Winata, Riviana Susanto, Dea Lambertha, and Felicia Wie as best friend for support, and help.
17. All of people who cannot be mentioned one by one.

The author realized that this report still far from perfection and might have some mistakes; therefore, the author would like to apologize for instance, and sincerely accept any suggestions given to the author for this thesis report. The author also hopes that this report can be useful for the readers, and those who need. Thank You.

Tangerang, June 28th, 2018

(FRANZ FERNANDO)

TABLE OF CONTENTS

	page
COVER	
STATEMENT OF THESIS AUTHENTICITY	
APPROVAL BY THESIS SUPERVISORS	
APPROVAL BY THESIS EXAMINATION COMMITTEE	
ABSTRACT	v
ACKNOWLEDGEMENTS	vi
TABLE OF CONTENTS	vii
LIST OF FIGURES	ix
LIST OF TABLES	x
LIST OF APPENDICES	xi
CHAPTER I INTRODUCTION	1
1.1 Background	1
1.2 Research Problem	2
1.3 Objectives	3
1.3.1 General Objectives	3
1.3.2 Specific Objectives	3
CHAPTER II LITERATURE REVIEW	4
2.1 Okara	4
2.2 Enzymatic Protein Hydrolysis	5
2.3 Solid State Fermentation (SSF)	6
2.4 Antioxidant	7
2.5 Peptides and Amino Acids as Antioxidant	8
2.6 Protein Quality	9
CHAPTER III RESEARCH METHODOLOGY	10
3.1 Materials and Equipment	10
3.2 Research Methods	11
3.2.1 Preliminary Research	11
3.2.1.1 Okara Characteristics Analysis	11
3.2.1.2 Growth Profiles of <i>Aspergillus oryzae</i>	12
3.2.1 Main Research	14
3.2.1.1 Influence of <i>A. oryzae</i> Initial Concentrations and Fermentation Times	14
3.2.1.2 Influence of Water Activity (a_w)	15
3.3 Experimental Design	16
3.3.1 Influence of <i>A. oryzae</i> Initial Concentrations and Fermentation Times	16
3.3.2 Influence of Water Activity (a_w)	18
3.4 Analyses	19
3.4.1 Antioxidant Activity (Rashad, <i>et al.</i> , 2011)	19

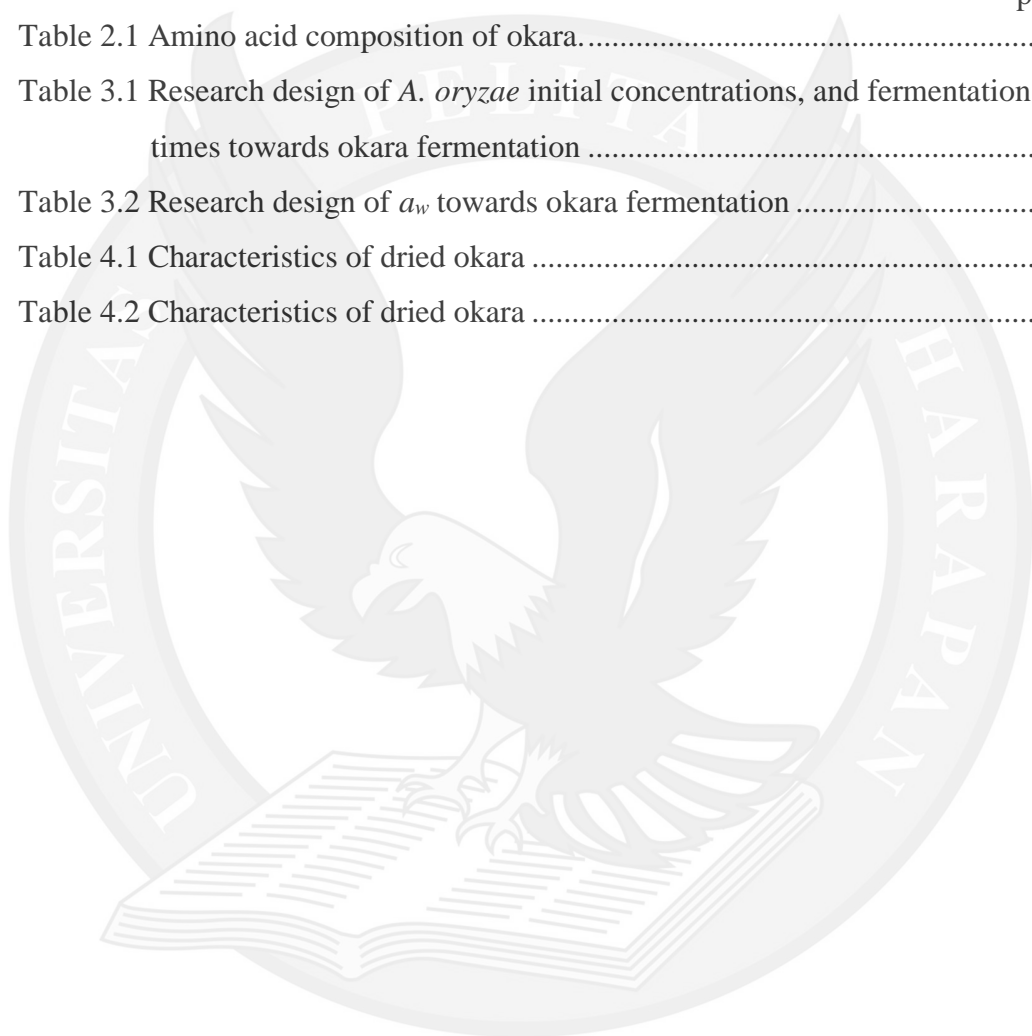
3.4.2 Degree of Hydrolysis (Morais, <i>et al.</i> , 2013).....	20
3.4.3 Protein Content (AOAC, 2005).....	20
3.4.4 Amino Nitrogen Content (Morais, <i>et al.</i> , 2013).....	21
3.4.5 <i>In vitro</i> Protein Digestibility (Almeida, <i>et al.</i> , 2011)	21
3.4.6 Amino Acids Profile (Rutherford and Gilani, 2008; and Narayan, <i>et al.</i> , 2011)	22
CHAPTER IV RESULTS AND DISCUSSION	23
4.1 Preliminary Research	23
4.2.1 Growth Profiles of <i>A. oryzae</i>	23
4.2.2 Characteristics of Dried Okara	26
4.3 Main Research	28
4.3.1 Influence of <i>A. oryzae</i> Initial Concentrations and Fermentation Times	28
4.3.2 Influence of Water Activity (a_w)	30
4.3.3 Comparison between Unfermented and Fermented Okara	32
4.3.4 Antioxidant Activity between Tofu, Tempeh, and Fermented Okara	35
CHAPTER V CONCLUSIONS AND SUGGESTIONS	37
5.1 Conclusions	37
5.2 Suggestions	38
BIBLIOGRAPHY	39
APPENDICES	44

LIST OF FIGURES

	page
Figure 2.1 Chemical reaction in oxidation process	8
Figure 3.2 Experimental flow diagram of <i>A. oryzae</i> growth curve	13
Figure 4.1 Growth profile of <i>Aspergillus oryzae</i> at 25°C.....	24
Figure 4.2 Growth profile of <i>Aspergillus oryzae</i> at 30°C.....	25
Figure 4.3 Growth profile of <i>Aspergillus oryzae</i> at 37°C.....	25
Figure 4.4 Macroscopic image of <i>A. oryzae</i>	26
Figure 4.5 Microscopic image of <i>A. oryzae</i> (magnification 400x).....	26
Figure 4.6 Influence of <i>A. oryzae</i> initial concentrations and fermentation times towards radical scavenging activity, fermentation condition: $a_w = 0.913$; $T = 30^\circ\text{C}$	28
Figure 4.7 Influence of <i>A. oryzae</i> initial concentrations and fermentation times towards degree of hydrolysis, fermentation condition: $a_w = 0.913$; $T = 30^\circ\text{C}$	29
Figure 4.8 Influence of water activity (a_w) towards radical scavenging activity, fermentation condition: $t = 96$ h; $T = 30^\circ\text{C}$	30
Figure 4.9 Influence of water activity (a_w) towards degree of hydrolysis, fermentation condition: $t = 96$ h; $T = 30^\circ\text{C}$	31
Figure 4.10 Amino acids profile comparison between unfermented and fermented okara (1.6×10^{-3} gDCW/gOkara <i>A. oryzae</i> initial concentrations; $a_w = 0.913$; $t = 96$ h; $T = 30^\circ\text{C}$).....	35
Figure 4.11 Comparison radical scavenging activity between tofu, tempeh, and fermented okara (1.6×10^{-3} gDCW/gOkara <i>A. oryzae</i> initial concentrations; $a_w = 0.913$; $t = 96$ h; $T = 30^\circ\text{C}$).....	36

LIST OF TABLES

	page
Table 2.1 Amino acid composition of okara.....	5
Table 3.1 Research design of <i>A. oryzae</i> initial concentrations, and fermentation times towards okara fermentation	18
Table 3.2 Research design of a_w towards okara fermentation	19
Table 4.1 Characteristics of dried okara	26
Table 4.2 Characteristics of dried okara	32



LIST OF APPENDICES

	page
Appendix A.	
Growth profile of <i>A. oryzae</i> at 25°C	A-1
Appendix B.	
Growth profile of <i>A. oryzae</i> at 30°C	B-1
Appendix C.	
Growth profile of <i>A. oryzae</i> at 37°C	C-1
Appendix D.	
Characteristics of dried okara	D-1
Appendix E.	
Initial concentrations of <i>A. oryzae</i>	E-1
Appendix F.	
Antioxidant activity of fermented okara ($T = 30^{\circ}\text{C}$; $a_w = 0.913$) at 5000 ppm	F-1
Appendix G.	
Statistical analysis result of fermented okara ($T = 30^{\circ}\text{C}$; $a_w = 0.913$) antioxidant activity.....	G-1
Appendix H.	
Amino nitrogen content of fermented okara ($T = 30^{\circ}\text{C}$; $a_w = 0.913$).....	H-1
Appendix I.	
Total nitrogen and protein content of fermented okara ($T = 30^{\circ}\text{C}$; $a_w = 0.913$)	I-1
Appendix J.	
Degree of hydrolysis of fermented okara ($T = 30^{\circ}\text{C}$; $a_w = 0.913$).....	J-1
Appendix K.	
Statistical analysis results of fermented okara ($T = 30^{\circ}\text{C}$; $a_w = 0.913$) degree of hydrolysis	K-1
Appendix L.	
Fermented okara (1.6×10^{-3} g _{DCW} /g _{Okara} <i>A. oryzae</i> initial concentration; $a_w = 0.931$; $t = 96$ h; $T = 30^{\circ}\text{C}$) analyses.....	L-1

Appendix M.	
Statistical analysis results of fermented okara (1.6×10^{-3} g _{DCW} /g _{Okara} <i>A. oryzae</i> initial concentrations; $a_w = 0.913$; $t = 96$ h; $T = 30^\circ\text{C}$) antioxidant activity and degree of hydrolysis with different water activity (a_w)	M-1
Appendix N.	
Statistical analysis results of functional characteristics between unfermented and fermented okara (1.6×10^{-3} g _{DCW} /g _{Okara} <i>A. oryzae</i> initial concentrations; $a_w = 0.913$; $t = 96$ h; $T = 30^\circ\text{C}$)	N-1
Appendix O.	
Antioxidant activity of tofu and tempeh at 5000 ppm	O-1
Appendix P.	
Statistical results of antioxidant activity of tofu, tempeh and fermented okara (1.6×10^{-3} g _{DCW} /g _{Okara} <i>A. oryzae</i> initial concentrations; $a_w = 0.913$; $t = 96$ h; $T = 30^\circ\text{C}$).	P-1
Appendix Q.	
Antioxidant activity of ascorbic acid at 5 ppm	Q-1
Appendix R.	
Particle size of dried okara	R-1
Appendix S.	
Unfermented okara protein digestibility	S-1
Appendix T.	
Fermented okara (1.6×10^{-3} g _{DCW} /g _{Okara} <i>A. oryzae</i> initial concentrations; $a_w = 0.913$; $t = 96$ h; $T = 30^\circ\text{C}$) protein digestibility	T-1
Appendix U.	
Unfermented okara amino acids profile	U-1
Appendix V.	
Fermented okara (1.6×10^{-3} g _{DCW} /g _{Okara} <i>A. oryzae</i> initial concentrations; $a_w = 0.913$; $t = 96$ h; $T = 30^\circ\text{C}$) amino acids profile	V-1