

TABLE OF CONTENTS

| | |
|---|-------------|
| TITLE PAGE | i |
| SUBMISSION PAGE | ii |
| ATTESTATION PAGE..... | iii |
| STATEMENT OF RESEARCH PROVISIONS..... | iv |
| ACKNOWLEDGEMENTS..... | v |
| SYMBOLS AND ABBREVIATIONS..... | vii |
| TABLE OF CONTENTS..... | ix |
| LIST OF FIGURES | xii |
| LIST OF TABLES | xiv |
| LIST OF APPENDICES | xv |
| ABSTRACT | xvi |
| INTISARI | xvii |
| CHAPTER I INTRODUCTION..... | 1 |
| 1.1. Background..... | 1 |
| 1.2. Objectives | 5 |
| CHAPTER II LITERATURE REVIEW..... | 6 |
| 2.1. Microencapsulation of Squalene (SQ)..... | 6 |
| 2.1.1. Squalene (SQ)..... | 6 |
| 2.1.2. Encapsulation | 8 |
| 2.1.3. Spray drying process | 12 |
| 2.2. Factors affecting the stability of SQ in spray-dried powder..... | 14 |
| 2.2.1. Oil-droplet diameter in powder | 14 |
| 2.2.2. Surface oil..... | 16 |
| 2.3. Lipid oxidation..... | 17 |
| CHAPTER III MATERIALS AND METHODS | 19 |
| 3.1. Materials | 19 |
| 3.1.1. Squalene (SQ)..... | 19 |
| 3.1.2. Maltodextrin (MD) | 19 |

| | |
|--|-----------|
| 3.1.3. Emulsifier | 20 |
| 3.1.4. Rosemary oil extract (RM) | 20 |
| 3.1.5. Iron (II) Sulfate Heptahydrate (Fe ₂ SO ₄) | 20 |
| 3.1.6. Squalane | 20 |
| 3.1.7. Chemicals | 21 |
| 3.2. Sample Preparations | 21 |
| 3.2.1. Encapsulation process | 24 |
| 3.2.2. Spray drying process | 25 |
| 3.3. Analytical Methods | 26 |
| 3.3.1. Oil-droplet and powder diameters | 26 |
| 3.3.2. Viscosity | 28 |
| 3.3.3. Moisture content | 29 |
| 3.3.4. Scanning electron microscopy (SEM) | 29 |
| 3.3.5. Rancimat test | 30 |
| 3.3.6. Extraction of total oil and surface oil | 31 |
| 3.4. Data Analysis | 35 |
| 3.4.1. Encapsulated to total oil ratio | 35 |
| 3.4.2. Stability of SQ in powder | 35 |
| 3.4.3. Statistical Analysis | 37 |
| 3.5. Preliminary Experiments | 37 |
| 3.5.1. High-pressure homogenization at 50 MPa | 38 |
| 3.5.2. Mechanical homogenization with 60% solid content and 10,000 rpm atomizer speed | 39 |
| 3.5.3. Mechanical homogenization with 60% solid content and 30,000 rpm atomizer speed | 41 |
| CHAPTER IV RESULTS AND DISCUSSIONS | 42 |
| 4.1. Physical Characteristics of SQ in Emulsion | 42 |
| 4.2. Physical Characteristics of SQ in Spray-dried Powder | 45 |
| 4.2.1. Reconstituted oil-droplet diameter | 45 |
| 4.2.2. Encapsulated to total oil ratio | 47 |

| | |
|--|-----------|
| 4.2.3. Powder diameter, retention during spray drying, and moisture content | 48 |
| 4.3. Morphology Visualization of Spray-dried Powder by SEM | 50 |
| 4.4. Stability of SQ in Spray-dried Powder | 53 |
| 4.4.1. Rancimat test | 53 |
| 4.4.2. Degradation kinetics and storage stability of SQ in spray-dried powder..... | 56 |
| 4.5. Principal Component Analysis (PCA)..... | 70 |
| CHAPTER V CONCLUSION | 73 |
| REFERENCES | 74 |
| APPENDICES | 82 |