Table of Contents

| | Page |
|---------------------------------|------------------------------|
| Acknowledgement | iii |
| Thai abstract | iv |
| English abstract | v |
| Table of Contents | vii |
| List of Tables | xii |
| List of Figures | xv |
| Abbreviation and symbols | xviii |
| Chapter 1 Introduction | 1 |
| Chapter 2 Literature review | 6 |
| 2.1 Beans | 6 |
| 2.2 Pasteurization | 21 |
| 2.3 Probiotic | 24 |
| 2.4 Prebiotics | 39 |
| 2.5 Microencapsulation | 45 |
| Chapter 3 Materials and Methods | 493 813 |
| 3.1 Raw material | 49 |
| 3.2 Probiotic microorganism | Mai ₄₉ University |
| 3.3 Equipment | e s492 r v e o |
| 3.4 Chemical reagent | 51 |
| 3.5 Microbiological media | 52 |

| | Page |
|---|---------------|
| 3.6 Methods | 52 |
| 3.6.1 Preparation and maintenance of Lactobacillus | |
| acidophilus TISTR 450 | 52 |
| 3.6.2 Preparation of bean milk | 52 |
| 3.6.3 Study the effect of different types of bean milk | |
| on the survival of L. acidophilus during storage in | |
| bean milk at 4°C for 15 days | 53 |
| 3.6.4 The effects of pH values and casein concentrations | |
| on the survival of L. acidophilus in bean milk | 1 306 |
| during 15 days storage at 4°C | 56 |
| 3.6.5 Investigation of an immobilized technique | |
| (an extrusion method) and initial concentrations of | |
| L. acidophilus in supporting the survival of the | |
| probiotic bacterium during storage in bean milk at | |
| 4°C for 15 days | 57 |
| 3.6.6 Evaluation for the survival of <i>L. acidophilus</i> | |
| in simulated gastrointestinal conditions during the | |
| shelf-life of the <i>L. acidophilus</i> in bean milk at 4°C | i University |
| for 15 days | 860 e r v e d |
| 3.7 Experimental designs and statistical analysis | 62 |

| | Page |
|---|--------------|
| Chapter 4 Result and Discussion | 63 |
| 4.1 Study the effect of different types of bean milk on | |
| the survival of L. acidophilus during storage in | |
| bean milk at 4°C for 15 days | 63 |
| 4.1.1 Chemical composition of bean milk | 63 |
| 4.1.2 The survival of L. acidophilus during 15 days | |
| storage in bean milk at 4°C | 64 |
| 4.1.3 Chemical properties of different types of bean milk | |
| added with L. acidophilus during 15 days storage | 300 |
| at 4°C | 68 |
| 4.1.4 Physical properties of different types of bean milk added | / 3 // |
| with <i>L. acidophilus</i> during 15 days storage at 4°C | 73 |
| 4.2 The effects of pH values and casein concentrations on the | |
| survival of L. acidophilus in mung bean milk during 15 days | |
| storage at 4°C | 77 |
| 4.2.1 The survival of L. acidophilus in mung bean milk | ยีกรใน |
| affected by different pH values and casein | iogoinr |
| concentrations during 15 days storage at 4°C | 78University |
| 4.2.2 Chemical properties of mung bean milk added | |
| with L. acidophilus and affected by different | |
| pH values and casein concentrations during | |
| 15 days storage at 4°C | 83 |

| | Page |
|--|--------|
| 4.2.3 Physical properties of mung bean milk added | |
| with L. acidophilus and affected by different pH | |
| values and casein concentrations during 15 days | |
| storage at 4°C | 92 |
| 4.3 The effects of initial concentrations of L. acidophilus and an | 1.3 |
| immobilized technique (an extrusion method) on the survival | 131 |
| of the probiotic bacterium in mung bean milk during 15 days | - - |
| storage at 4°C | 96 |
| 4.3.1 The survival of <i>L. acidophilus</i> in mung bean milk | |
| affected by initial concentrations of the probiotic | 7 4 // |
| bacterium and an immobilization technique during | / 5 // |
| 15 days storage at 4°C | 97 |
| 4.3.2 Chemical properties of mung bean milk added | |
| with L. acidophilus and affected by initial | 3 |
| concentrations of the probiotic bacterium and | |
| an immobilization technique during 15 day | |
| storage at 4°C | 101 |
| 4.3.3 Physical properties of mung bean milk added | |
| with L. acidophilus and affected by initial | SALVAO |
| concentrations of the probiotic bacterium and | |
| an immobilization techniqueduring 15 days | |
| storage at 4°C | 106 |

| | Page |
|--|------|
| 4.4 The survival of L. acidophilus in simulated gastrointestinal | |
| conditions during the shelf-life of the L. acidophilus in | |
| mung bean milk at 4°C for 15 days | 110 |
| 4.4.1 The survival of <i>L. acidophilus</i> in simulated | |
| high-acid gastric conditions during the shelf-life | 1.21 |
| of the L. acidophilus in mung bean milk at 4°C | 131 |
| for 15 days | 111 |
| 4.4.2 The survival of <i>L. acidophilus</i> in simulated | |
| bile-salt conditions during the shelf-life of the | |
| L. acidophilus in mung bean milk at 4°C for 15 days | 114 |
| Chapter 5 Conclusion | 118 |
| References | 121 |
| Appendices | 132 |
| Appendix A Methods for chemical and physical analysis | 133 |
| Appendix B Methods for microbiological analysis | 140 |
| Appendix C Figures | 143 |
| Curriculum Vitae | |
| Copyright [©] by Chiang Ma | |
| All rights res | |
| | |

List of Tables

| Tables | | Page |
|-----------|--|----------------|
| Table 2.1 | Nutritional values for the edible portion of raw | |
| | mature soybeans (Glycine max) seeds | 7 |
| Table 2.2 | Nutritional values for the edible portion of raw | |
| | mature red kidney bean (Phaseolus vulgasris) seeds | 10 |
| Table 2.3 | Nutritional values for the edible portion of raw | |
| | mature black bean (Phaseolus vulgaris) seeds | 14 |
| Table 2.4 | Nutritional values for the edible portion of raw | |
| | mature mung bean (Vigna radiata) seeds | 17 |
| Table 4.1 | Chemical composition of bean milk | 64 |
| Table 4.2 | Viability slopes of different microorganism groups | |
| | in different types of bean milk during 15 days | |
| | storage at 4°C | 66 |
| Table 4.3 | Slopes for the chemical properties of different types of | |
| | bean milk during 15 days storage at 4°C | 69 |
| Table 4.4 | Physical properties of different types of bean milk | แชียอใหม |
| | added with L. acidophilus during 15 days storage at 4°C | 74 |
| Table 4.5 | Slopes for the physical properties of different types of | al Ciliversity |
| | bean milk added with L. acidophilus during 15 days | |
| | storage at 4°C | 75 |

List of Tables (continued)

| Tables | | Page | • |
|------------|---|----------|---------|
| Table 4.6 | Viability slopes of different microorganism groups | | |
| | in mung bean milk added with L. acidophilus | | |
| | affected by different pH values and casein concentrations | 2/5 | |
| | during 15 days storage at 4°C | 80 | |
| Table 4.7 | Slopes for the chemical properties of mung bean | | 3 |
| | milk added with L. acidophilus and affected by | | |
| | different pH values and casein concentrations | <u> </u> | |
| | during 15 days storage at 4°C | 85 | |
| Table 4.8 | Physical properties of mung bean milk added with | | |
| | L. acidophilus and affected by different pH values and | | |
| | casein concentrations during 15 days storage at 4°C | 93 | |
| Table 4.9 | Slopes for the physical properties of mung bean milk | | |
| | added with L. acidophilus and affected by different pH | | |
| | values and casein concentrations during 15 days | | |
| | storage at 4°C | 95 | |
| Table 4.10 | Viability slopes of different microorganism groups | 11891 | |
| | in mung bean milk affected by initial concentrations | | |
| | of the L. acidophilus and an immobilization technique | ai Uni | versity |
| | during 15 days storage at 4°C | 100 | |

List of Tables (continued)

| Tables | Page |
|---|-----------------|
| Table 4.11 Slopes of chemical properties change of mung bean milk | |
| added with L. acidophilus and affected by initial | |
| concentrations of the probiotic bacterium and an | |
| immobilizationtechnique during 15 days storage at 4°C | 103 |
| Table 4.12 Physical properties of mung bean milk added with | |
| L. acidophilus and affected by initial concentrations | |
| of the probiotic bacterium and an immobilization technique | |
| during 15 days storage at 4°C | 108 |
| Table 4.13 Slopes of physical properties of mung bean milk | 900 |
| added with L. acidophilus and affected by initial | |
| concentrations of the probiotic bacterium and an | |
| immobilization technique during 15 days storage at 4°C | 109 |
| Table 4.14 The survival of <i>L. acidophilus</i> in simulated high-acid | |
| gastric conditions during the shelf-life of the L. acidophilus | |
| in mung bean milk at 4°C for 15 days | 112 |
| Table 4.15 The survival slopes of <i>L. acidophilus</i> in simulated | เหยางใหา |
| high-acid gastric conditions during the shelf-life | |
| of the L. acidophilus in mung bean milk at 4°C for 15 days | iii4 Iniversity |
| Table 4.16 The survival slopes of <i>L. acidophilus</i> in bile-salt | served |
| conditions during the shelf-life of the L. acidophilus | |
| in mung bean milk at 4°C for 15 days | 117 |

List of Figures

| Figures | | Page |
|------------|---|--------------------|
| Figure 2.1 | Fructo-oligosaccharides | 41 |
| Figure 4.1 | The number of L. acidophilus in different types of bean | 8 |
| | milk during 15 days storage at 4°C | 65 |
| Figure 4.2 | Total plate count of different types of bean milk | 3 |
| | added with L. acidophilus during 15 days storage at 4°C | 67 |
| Figure 4.3 | Total soluble solid (°Brix) of different types of bean milk | |
| | during 15 days storage at 4°C | 69 |
| Figure 4.4 | Total titratable acidity (% lactic acid) of different types | |
| | of bean milk during 15 days storage at 4°C | 70 |
| Figure 4.5 | pH value of different types of bean milk during 15 days | |
| | storage at 4°C | 72 |
| Figure 4.6 | The number of L. acidophilus in mung bean milk affected | \$ [\] // |
| | by different pH values and casein concentrations during | |
| | 15 daysstorage at 4°C | 79 |
| Figure 4.7 | Total plate count of mung bean milk added with | |
| | L. acidophilus and affected by different pH values | |
| | and casein concentrations during 15 days storage at 4°C | 82 |
| Figure 4.8 | Total soluble solid (°Brix) of mung bean milk added with | served |
| | L. acidophilus and affected by different pH values | |
| | and casein concentrations during 15 days storage at 4°C | 84 |
| | | |

List of Figures (continued)

| Figures | | Page |
|-------------|---|----------------------------|
| Figure 4.9 | Total titratable acidity (% lactic acid) of mung bean milk | |
| | added with L. acidophilus and affected by different pH values | |
| | and casein concentrations during 15 days storage at 4°C. | . 87 |
| Figure 4.10 | pH value of mung bean milk added with L. acidophilus | 301 |
| | and affected by different pH values and casein concentrations | |
| | during 15 days storage at 4°C | 89 |
| Figure 4.11 | Protein content of mung bean milk added with | |
| | L. acidophilus and affected by different pH values | 53 |
| | and casein concentrations during 15 days storage at 4°C | 91 |
| Figure 4.12 | The number of L. acidophilus in mung bean milk | |
| | affected by initial concentrations of the probiotic bacterium | 2 / |
| | and an immobilization technique during 15 days storage at 4°C | 98 |
| Figure 4.13 | Total plate count of mung bean milk affected by initial | 517 |
| | concentrations of the L. acidophilus and an immobilization | |
| | technique during 15 days storage at 4°C | 101 |
| Figure 4.14 | Total soluble solid (°Brix) of mung bean milk affected | แห่งเกใหม |
| | by initial concentrations of the L. acidophilus and an | |
| | immobilization technique during 15 days storage at 4°C | 1 ₁₀₂ miversity |
| Figure 4.15 | Total titratable acidity (% lactic acid) of mung bean milk | served |
| | affected by initial concentrations of L. acidophilus | |
| | and an immobilization technique during 15 days | |
| | storage at 4°C | 104 |

List of Figures (continued)

| Figures | | Page |
|-------------|---|------|
| Figure 4.16 | pH value of mung bean milk affected by initial | |
| | concentrations of L. acidophilus and an immobilization | |
| | technique during 15 days storage at 4°C | 106 |
| Figure 4.17 | The survival of L. acidophilus and in simulated bile-salt | |
| | conditions during the shelf-life of the L. acidophilus in | |
| | mung bean milk at 4°C for 15 days | 115 |
| Figure C1 | Bean milk | 144 |
| Figure C2 | Gram staining of Lactobacillus acidophilus TISTR 450 | 145 |
| Figure C3 | A calcium-alginate bead contained Lactobacillus acidophilus | |
| | TISTR 450 cells | 145 |

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved

ABBREVIATION AND SYMBOLS

Cm = centimeter

CFU/ml = Colony Forming Unit per milliliter

^oC = degree centigrade

Cp = centipoise

G = gram

Kcal = kilocalory

Mg milligram

Ml = milliliter

Mm = millimeter

Mg/g = milligram per gram

MRS = de Man Rogosa Sharpe

 μl = microliter

μm = micrometer

M = molarity

N = normality

Nm = nanometer

pH = power of hydrogen ion

w/v = weight by volume

w/w = weight by weight

% = percentage