CONTENTS

| | | Page |
|----|--|--------|
| Co | ontents | (x) |
| Li | st of tables | (xiii) |
| Li | st of figures | (xiv) |
| Cł | napter | |
| 1. | Introduction | 1 |
| | Literature review | 3 |
| | 1. Muscle protein composition | 3 |
| | 2. Gelation of muscle protein | 7 |
| | 3. Proteolytic enzyme | 11 |
| | 4. Proteinase inhibitor | 13 |
| | 5. Phosphate compound | 17 |
| | 6. Improvement of gel quality | 21 |
| | 7. Transglutaminase | 22 |
| | 8. Hydrocolloids or gums | 29 |
| Oł | pjectives | 37 |
| 2. | Materials and methods | |
| | 1. Materials | 38 |
| | 2. Instruments | 39 |
| | 3. Methods | 39 |
| | 3.1. Study on the gel properties of Pacific white shrimp meat | |
| | 3.1.1 Effect of sodium chloride concentrations on gel properties of | 39 |
| | Pacific white shrimp meat | |
| | 3.1.2 Effect of pyrophosphate in combination with magnesium chloride | 42 |
| | and/or calcium chloride on gel properties of Pacific white shrimp | |
| | meat | |
| | 3.2. The effect of some protein additives on gel properties of Pacific white | 43 |
| | shrimp meat | |

CONTENTS (Continued)

| | Page |
|--|------|
| 3.3. Study on autolysis of Pacific white shrimp meat | |
| 3.3.1 Effect of temperature on autolysis of Pacific white shrimp mince | 44 |
| 3.3.2 Effect of pH on autolysis of Pacific white shrimp mince | 44 |
| 3.3.3 Effect of inhibitors on autolytic activity of Pacific white shrimp | 45 |
| mince | |
| 3.3.4 Effect of some protein additives on autolysis of Pacific white shrimp | 45 |
| mince | |
| 3.4. The effect of setting condition on gel properties of Pacific white | |
| shrimp meat | |
| 3.4.1 Characterization of endogenous TGase | 45 |
| 3.4.2 Effect of setting condition on gel properties | 46 |
| 3.4.3 Effect of CaCl ₂ concentrations on gel properties | 46 |
| 3.5. The effect of MTGase on gel properties of Pacific white shrimp meat | 47 |
| 3.6 The effect of hydrocolloids on freeze-thaw stability of Pacific white | 47 |
| shrimp gel | |
| 4. Statistical analysis | 48 |
| 3. Results and discussion | |
| 1. Gel properties of Pacific white shrimp meat | 49 |
| 1.1 Effect of sodium chloride concentrations on gel properties of Pacific white | 49 |
| shrimp meat | |
| 1.2 Effect of pyrophosphate in combination with magnesium chloride and/or | 56 |
| calcium chloride on gel properties of Pacific white shrimp meat | |
| 2. Effect of some protein additives on gel properties of Pacific white shrimp meat | 65 |
| | |

CONTENTS (Continued)

| | Page |
|---|------|
| 3. Autolysis of Pacific white shrimp meat | |
| 3.1 Effect of temperature on autolysis of Pacific white shrimp mince | 78 |
| 3.2 Effect of pH on autolysis of Pacific white shrimp mince | 81 |
| 3.3 Effect of inhibitors on autolytic activity of Pacific white shrimp mince | 82 |
| 3.4 Effect of protein additives on autolysis of Pacific white shrimp mince | 85 |
| 4. Effect of setting condition on gel properties of Pacific white shrimp meat | |
| 4.1 Characterization of endogenous TGase | 90 |
| 4.2 Effect of setting condition on gel properties | 92 |
| 4.3 Effect of CaCl ₂ concentrations on gel properties | 100 |
| 5. Effect of MTGase on gel properties of Pacific white shrimp meat | 109 |
| 6. Effect of hydrocolloids on freeze-thaw stability of Pacific white shrimp gel | 115 |
| 4. Conclusion | 124 |
| Future researches | 126 |
| References | 127 |
| Appendix | 155 |
| Vitae | 162 |

LIST OF TABLES

| Ta | Table | |
|----|---|-----|
| 1. | Contractile proteins in food myosystems | 4 |
| 2. | Conformation changes occurring during the thermal denaturation of natural | 8 |
| | actomyosin | |
| 3. | Selected source of protease inhibitors | 14 |
| 4. | Sources and characteristics of some TGase | 24 |
| 5. | TGase activity level in the various fish muscles and surimi | 29 |
| 6. | Expressible moisture content and color of gels from Pacific white shrimp meat | 52 |
| | containing different NaCl levels (2-4%) | |
| 7. | Expressible moisture content and color of gels from Pacific white shrimp meat at | 61 |
| | different concentrations of PP in combination with MgCl ₂ and/or CaCl ₂ | |
| 8. | Expressible moisture content of one-step heated gels from Pacific white shrimp | 71 |
| | meat added with different types and concentrations of protein additives | |
| 9. | Expressible moisture content of two-step heated gels from Pacific white shrimp | 72 |
| | meat added with different types and concentrations of protein additives | |
| 10 | . Effect of various protease inhibitors on Pacific white shrimp meat autolysis | 84 |
| | in the presence and in the absence of 2.5%NaCl | |
| 11 | Expressible moisture content and color of gels from Pacific white shrimp meat | 95 |
| | added with CaCl ₂ with and without PP/MgCl ₂ during setting at 55°C for different | |
| | times | |
| 12 | Expressible moisture content and color of Pacific white shrimp gels (2.5% NaCl+ | 104 |
| | 5mmolePP/kg+5mmoleMgCl ₂ /kg) in the presence of different CaCl ₂ | |
| | concentrations | |
| 13 | Expressible moisture content of gels from Pacific white shrimp meat (5mmolePP/ | 111 |
| | kg + 5 mmoleMgCl ₂ /kg + 50 mmoleCaCl ₂ /kg) in the presence of MTGase at | |
| | different levels | |

LIST OF FIGURES

| Fig | Sigure Sigure | |
|-----|--|----|
| 1. | Model of myosin molecule | 5 |
| 2. | Thin filament of muscle formed by the filament of tropomyosin molecules wound | 7 |
| | in each of the two grooves of the actin helix and proposed model for configuration | |
| | of actin, tropomysin and troponin (Tn) subunits | |
| 3. | Formation of a gel network structure | 9 |
| 4. | A schematic representation of the thermal aggregation of fish myosin | 10 |
| 5. | Action of endopeptidase and exopeptidase on protein structure | 12 |
| 6. | Reaction catalyzed by TGase | 23 |
| 7. | Primary structure of microbial transglutaminase (MTGase): all amino acids are | 26 |
| | denoted by the letter codes; *, indicates the possible active cysteine residue | |
| 8. | The structure of starch (a) amylose (b) amylopectin | 30 |
| 9. | The gel formation of starch | 31 |
| 10. | Formation of hydroxypropyl starch | 31 |
| 11. | A proposed mechanism of the freeze-thaw stabilizing effect of unretrogradable | 33 |
| | modified starch | |
| 12. | Structures of kappa-, iota-, and lambda-type carrageenans | 34 |
| 13. | Gelation of kappa and iota carrageenan | 35 |
| 14. | Cross-linking helical kappa carrageenan; (A) by binding of 'smooth' regions of | 35 |
| | locust bean gum; (B) the parts of the galactomannan which carry grouped galactose | |
| | substituents and which we term 'hairy' region; (C) form flexible connections | |
| | between helices | |
| 15. | Scheme for shrimp gel preparation | 40 |
| 16. | Breaking force and deformation of gels from Pacific white shrimp meat containing | 51 |
| | different NaCl levels (2-4%) | |
| 17. | TCA-soluble peptide content of gel from Pacific white shrimp meat containing | 54 |
| | different NaCl levels (2-4%) | |

| Figure | Page |
|--|------|
| 18. SDS-PAGE patterns of gel from Pacific white shrimp of meat containing | 55 |
| different NaCl levels (2-4%) | |
| 19. Microstructures of gels from Pacific white shrimp meat containing different NaCl | 56 |
| levels (%) | |
| 20. Breaking force and deformation of gels from Pacific white shrimp meat at different | 59 |
| concentrations of PP in combination with MgCl ₂ and/or CaCl ₂ | |
| 21. TCA-soluble peptide content of gels from Pacific white shrimp meat at different | 63 |
| concentrations of PP in combination with MgCl ₂ and/or CaCl ₂ | |
| 22. Protein patterns of gels from Pacific white shrimp meat at different concentrations | 64 |
| of PP in combination with MgCl ₂ and/or CaCl ₂ | |
| 23. Microstructures of gels from Pacific white shrimp meat containing 2.5% NaCl | 65 |
| added with 150mmoleCaCl ₂ /kg (a) 150 mmoleCaCl ₂ /kg + 5 mmolePP/kg (b) | |
| and 150 mmoleCaCl ₂ /kg + 5 mmolePP/kg + 5 mmoleMgCl ₂ /kg (c) | |
| 24. Breaking force and deformation of one-step heated gels from Pacific white shrimp | 66 |
| meat added with different types and concentrations of protein additives | |
| 25. Breaking force and deformation of two-step heated gels from Pacific white shrimp | 67 |
| meat added with different types and concentrations of protein additives | |
| 26. TCA-soluble peptide content of one-step and two-step heated gels from Pacific | 74 |
| white shrimp meat added with different types and concentrations of protein | |
| additives | |
| 27. Protein patterns of one-step and two-step heated gels from Pacific white shrimp | 76 |
| meat added with different types and concentrations of protein additives | |
| 28. Microstructures of gels from Pacific white shrimp meat added with different types | 77 |
| and concentrations of protein additives | |
| 29. TCA-soluble peptide content of gel from Pacific white shrimp mince incubated at | 79 |
| different temperatures for 30 and 60 min in the presence and in the absence of 2.5% | |
| NaCl | |

| Figure | Page |
|---|------|
| 30. Protein patterns of Pacific white shrimp mince incubated at different temperatures | 80 |
| for 30 and 60 min in the presence and absence of 2.5% NaCl | |
| 31. TCA-soluble peptide content of Pacific white shrimp mince incubated at differents | 82 |
| pH values (2-10) at 40°C for 60 min in the presence of 2.5% NaCl and 35°C for | |
| 60 min in the absence of 2.5% NaCl | |
| 32. Protein patterns of Pacific white shrimp mince incubated at different pH values at | 83 |
| 40°C for 60 min in the presence of 2.5% NaCl (a) and 35°C for 60 min in the | |
| absence of 2.5% NaCl | |
| 33. Protein patterns of Pacific shrimp mince incubated at 40 °C for 60 min in the | 86 |
| presence of 2.5% NaCl without and with proteinase inhibitors | |
| 34. Protein patterns of Pacific shrimp mince incubated at 35°C for 60 min in the | 87 |
| absence of 2.5% NaCl without and with proteinase inhibitors | |
| 35. TCA-soluble peptide content of Pacific white shrimp mince incubated at 40 °C for | 88 |
| 60 min in the presence of 2.5% NaCl and added with various protein additives at | |
| different concentrations | |
| 36. Protein patterns of Pacific white shrimp mince incubated at 40°C for 60 min in | 89 |
| the presence of 2.5% NaCl and added with various protein additives at different | |
| concentrations | |
| 37. Effect of temperature on TGase activity of crude extract from Pacific white shrimp | 91 |
| muscle | |
| 38. Effect of CaCl ₂ concentrations on TGase activity of crude extract from Pacific | 91 |
| white shrimp muscle | |
| 39. Breaking force and deformation of gels from Pacific white shrimp meat added with | 94 |
| CaCl ₂ with and without PP/MgCl ₂ during setting at 55 °C for different times | |
| 40. TCA-soluble peptide content of gels from Pacific white shrimp meat added with | 98 |
| CaCl ₂ with and without PP/MgCl ₂ during setting at 55°C for different times. | |

| Fig | ure | Page |
|-----|--|------|
| 41. | Solubility of Pacific white shrimp gels added with CaCl ₂ with and without | 98 |
| | PP/MgCl ₂ during setting at 55°C for different times | |
| 42. | Protein patterns of gels from Pacific white shrimp meat added with CaCl ₂ with and | 100 |
| | without PP/MgCl ₂ during setting at 55°C for different times | |
| 43. | Breaking force and deformation of Pacific white shrimp gels (2.5%NaCl +5 mmole | 101 |
| | PP/kg + 5 mmoleMgCl ₂ /kg) in the presence of different CaCl ₂ concentrations | |
| 44. | TCA soluble peptide content of Pacific white shrimp gels (2.5%NaCl + 5mmolePP/ | 105 |
| | kg + 5mmoleMgCl ₂ /kg) in the presence of different CaCl ₂ concentrations | |
| 45. | Solubility of Pacific white shrimp gels (2.5%NaCl+5mmolePP/kg+ 5mmoleMgCl ₂ / | 107 |
| | kg) in the presence of different CaCl ₂ concentrations | |
| 46. | Protein patterns of Pacific white shrimp gels (2.5%NaCl + 5mmolePP/kg + | 108 |
| | 5mmole MgCl ₂ /kg) in the presence of different CaCl ₂ concentrations | |
| 47. | Breaking force and deformation of gels from Pacific white shrimp meat (5mmole | 110 |
| | PP/kg + 5 mmoleMgCl ₂ /kg + 50 mmoleCaCl ₂ /kg) in the presence of MTGase at | |
| | different levels. | |
| 48. | TCA-soluble peptide content of gels from Pacific white shrimp meat (5mmolePP/kg | 112 |
| | + 5 mmoleMgCl ₂ /kg + 50 mmoleCaCl ₂ /kg) in the presence of MTGase at different | |
| | levels. | |
| 49. | Solubility of gels from Pacific white shrimp meat (5mmolePP/kg + 5 mmoleMgCl ₂ | 112 |
| | /kg+ 50 mmoleCaCl ₂ /kg) in the presence of MTGase at different levels. | |
| 50. | Protein patterns of gels from Pacific white shrimp meat (5mmolePP/kg + 5 mmole | 113 |
| | $MgCl_2/kg + 50 \text{ mmoleCaCl}_2/kg$) in the presence of MTGase at different levels. | |
| 51. | Breaking force and deformation of gels from Pacific white shrimp meat added with | 117 |
| | modified starch at different levels and subjected to different freeze-thaw cycles | |
| 52. | Breaking force and deformation of gels from Pacific white shrimp meat added with | 118 |
| | <i>l</i> -carrageenan at different levels and subjected to different freeze-thaw cycles | |

| Figure | | Page |
|--------|--|------|
| 53. | Expressible moisture content of gels form Pacific white shrimp meat added with | 121 |
| | modified starch or l -carrageenan at different levels and subjected to different | |
| | freeze-thaw cycles | |
| 54. | Microstructures of Pacific white shrimp gels added without and with 2% modified | 123 |
| | starch and subjected to different freeze-thaw cycles. | |