#### Contents

	Page
บทคัด ย่อ	(3)
Abstract	(5)
Acknowledgement	(7)
Contents	(8)
List of Tables	(14)
List of Figures	(15)
Chapter	
1. Introduction	1
Literature review	3
1. Blood and plasma	3
1.1 Composition of the blood	3
1.2 Blood plasma	5
1.3 Blood processing	6
1.4 Utilization of blood and plasma	7
2. Lipid oxidation	9
1.1 Initiation	9
1.2 Propagation	10
1.3 Termination	11
3. Antioxidants	11

3.1 Classification of food antioxidants	12
3.2 Mode of action of antioxidants in food	14

4. Maillard reaction	17
4.1 Stages of Maillard reaction	18
4.2 Factors affecting Maillard reaction	23
4.3 The antioxidative activity of Maillard reaction products	29
4.4 The antioxidative stability of MRPs	34
5. Application of Maillard reaction products	35
Objectives	38
2. Materials and methods	39
1. Materials	39
2. Instruments	40
3. Methods	40
3.1 Preparation of porcine plasma protein	40
3.2 Effect of sugar types and heating time on the characteristics and	t
antioxidant activity of Maillard reaction products (MRPs) from	1
PPP-sugar model system	41
3.3 Effect of pHs on the characteristics and antioxidant activity o	f
MRPs from PPP-glucose model system	43
3.4 Characteristics and antioxidative activity of MRPs from PPH	5
hydrolysate-glucose model system	44
	46

2.

3.5 Fractionation of PPP acid hydrolysate-glucose MRPs	
	47
3.6 Decolorization of PPP acid hydrolysate-glucose MRPs	

		Page
	3.7 Study on antioxidant activity of MRPs and decolorized MRPs	49
	3.8 Study on the antioxidant activity of MRPs and decolorized MRPs	
	during storage	50
	3.9 Uses of MRPs in sardine mince and sardine emulsion sausage	50
	4. Statistical analysis	52
3.	Results and discussion	53
	1. Effect of sugars and heating time on the characteristics and antioxidative	
	activity of Maillard reaction products (MRPs)	53
	1.1 Changes in pH	53
	1.2 Changes in A <sub>294</sub>	54
	1.3 Changes in fluorescence intensity	54
	1.4 Changes in browning intensity	56
	1.5 Changes in free amino group content	58
	1.6 Changes in reducing power	60
	1.7 Changes in DPPH radical-scavenging activity	60
	1.8 Effect of MRP amounts on antioxidative activity	61
	2. Effect of pH on characteristics and antioxidative activity of MRPs	
	from PPP-glucose model system	64
	2.1 Changes in pH	64

2.2 Changes in A <sub>294</sub>	65
2.3 Changes in fluorescence intensity	65

2.4 Changes in browning intensity	66
2.5 Changes in free amino group content	68
2.6 Changes in reducing sugar content	69
2.7 Changes in reducing power	71
2.8 Changes in DPPH radical-scavenging activity	71
3. Characteristics and antioxidative activity of MRPs from PPP	
hydrolysate-glucose model system	73
3.1 Enzymatic hydrolysis of porcine plasma protein	73
3.2 Acid hydrolysis of porcine plasma protein	75
3.3 Changes in pH	76
3.4 Changes in A <sub>294</sub>	77
3.5 Changes in fluorescence intensity	78
3.6 Changes in browning intensity	79
3.7 Changes in free amino group content	81
3.8 Changes in reducing sugar content	81
3.9 Changes in reducing power	84
3.10 Changes in DPPH radical-scavenging activity	85
3.11 Changes in metal chelating activity	86
4. Characteristics and antioxidative activity of PPP acid hydrolysate-	

glucose MRP fractions	88
4.1 Browning intensity of various MRPs fractions	88
4.2 Reducing power of various MRPs fractions Contents (Continued)	89
	Page
4.3 Radical-scavenging activity of various MRPs fractions	90
4.4 Metal chelating activity of various MRPs fractions	91
5. Effect of decolorization on color and antioxidative activity of MRPs	
from PPP acid hydrolysate-glucose model system	93
5.1 Color of MRPs and decolorized MRPs powder	93
5.2 Browning intensity of MRPs and decolorized MRPs	94
5.3 Reducing power of MRPs and decolorized MRPs	96
5.4 Radical-scavenging activity of MRPs and decolorized MRPs	97
5.5 Metal chelating activity of MRPs and decolorized MRPs	98
6. Characteristic and antioxidative activity of MRPs and decolorized MR	Ps 100
6.1 Color of MRPs and decolorized MRPs solution	100
6.2 The effect of MRPs and decolorized MRPs amount on antioxidati	ve
activity	101
6.3 Hydroxyl radical-scavenging activity of MRPs and decolorized	
MRPs	103
$6.4 H_2O_2$ scavenging activity of MRPs and decolorized MRPs at	
different levels	104
6.5 Antioxidative activity of MRPs and decolorized MRPs in differen	t
systems	106

6.6 The changes in antioxidative activity of MRPs and decolorized	
MRPs during storage at 4°C and 25°C	110
7. Application of MRPs and decolorized MRPs to retard the lipid oxidation	
in sardine mince and sardine emulsion sausage	112
7.1 Uses of MRPs and decolorized MRPs in sardine mince	112
7.2 Uses of MRPs in sardine emulsion sausage	114
4. Conclusion	120
References	122
Appendix	150
Publications	
Vitae	159

Page

#### List of tables

Та	Table	
1	Blood components and their functions	3
2	Concentrations (mg/ml) of some blood constituents in the goat, cow and	
	pig	4
3	Compositional analysis of plasma protein sample	6
4	Antioxidant activity of Maillard reaction products	31
5	L* (lightness), a* (redness/greeness) and b* (yellowness/blueness)-values	
	of MRPs powder decolorized by activated carbon or Sep-Pak Cartridge	
	C <sub>18</sub>	94

## List of Figures

Fig	Figure	
1	Nonenzymatic browning	18
2	Early stage of Maillard reaction	19
3	Degradation of Amadori compound	21
4	Scheme for sardine emulsion sausage production	51
5	Changes in pH of various PPP-sugar MRPs during heating for different	
	times	53
6	Changes in $A_{294}$ (a), fluorescence intensity (b) and browning intensity (c)	
	of various PPP-sugar MRPs during heating for different times	57
7	Changes in free amino group content of various PPP-sugar MRPs during	
	heating for different times	59
8	Reducing power (a) and DPPH radical-scavenging activity (b) of various	
	PPP-sugar MRPs during heating for different times	62
9	Reducing power (a) and DPPH radical-scavenging activity (b) of various	
	PPP-sugar MRPs with different amounts	63
10 Changes in pH of PPP-glucose MRPs with various initial pHs during		
	heating for different times	64
11	Changes in $A_{294}$ (a), fluorescence intensity (b) and browning intensity (c)	

# of PPP-glucose MRPs with various initial pHs during heating for different times

### List of Figures (Continued)

Figure		Page
12	Changes in free amino group content (a) and reducing sugar content (b) of	
	PPP-glucose MRPs with various initial pHs during heating for different	
	times	70
13	Reducing power (a) and DPPH radical-scavenging activity (b) of PPP-	
	glucose MRPs with various initial pHs during heating for different times	72
14	The relationship between $log_{10}$ (alcalase amount) versus DH(%) in	
	enzymatic hydrolysis of PPP for 4 h at pH 8.5 and 60°C	74
15	The relationship between $log_{10}$ (heating time) versus DH(%) in acid	
	hydrolysis of PPP in 4 N HCl	75
16	Changes in pH of PPP hydrolysate-glucose MRPs with various hydrolysis	
	processes and DHs	76
17	Changes in $A_{294}$ (a), fluorescence intensity (b) and browning intensity (c)	
	of PPP hydrolysate-glucose MRPs with various hydrolysis processes and	
	DHs	80
18	Changes in free amino group incorporated (a) and reducing sugar	
	content (b) of PPP hydrolysate-glucose MRPs with various hydrolysis	
	processes and DHs	83
19	Reducing power (a), DPPH radical-scavenging activity (b) and metal	

(12)

67

chelating activity (c) of PPP hydrolysate-glucose MRPs with various	
hydrolysis processes and DHs	

## List of Figures (Continued)

Figure		
20 Browning intensity of different PPP-acid hydrolysate-glucose MRPs		
fractions	89	
21 Reducing power (a), DPPH radical-scavenging activity (b) and metal		
chelating activity (c) of MRPs and different fractions at various		
concentrations	92	
22 Browning intensity of MRPs and MRPs decolorized by activated carbon		
and Sep-Pak Cartridge C18	95	
23 Reducing power (a), DPPH radical-scavenging activity (b) and metal		
chelating activity (c) of MRPs and MRPs decolorized by activated carbon		
and Sep-Pak Cartridge C18	99	
24 L* (lightness), a* (redness/greeness) and b* (yellowness/blueness)-values		
of MRPs and decolorized MRPs solution (6%, w/v)	100	
25 Reducing power (a), DPPH radical-scavenging activity (b) and metal		
chelating activity (c) of MRPs and decolorized MRPs with different		
amounts	102	
26 Hydroxyl radical-scavenging activity of MRPs and decolorized MRPs	103	
27 Hydrogen peroxide scavenging activity of MRPs and decolorized MRPs	105	
28 Changes in TBARS (a) and conjugated diene (b) in soybean lecithin		
liposome system in the absence or presence of MRPs and decolorized		

87

MRPs at different levels	107		
29 Changes in $\beta$ -carotene bleaching in the absence or presence of MRPs and			
decolorized MRPs at different levels List of Figures (Continued)	109		
Figure	Page		
30 Changes in reducing power (a), DPPH radical-scavenging activity (b) and			
metal chelating activity (c) of MRPs and decolorized MRPs during storage			
at 4°C and 25°C for 8 weeks	111		
31 Changes in TBARS of sardine mince added with MRPs or decolorized			
MRPs (D-MRPs) at different levels during iced storage for 15 days	113		
32 Changes in TBARS of sardine emulsion sausage without and with			
MRPs at different levels during storage at 4°C for 15 days	115		
33 Changes in peroxide values of sardine emulsion sausage without and with			
MRPs at different levels during storage at 4°C for 15 days	117		
34 Changes in conjugated diene of sardine emulsion sausage without and with			
MRPs at different levels during storage at 4°C for 15 days	119		