

UNIVERSITI PUTRA MALAYSIA

PREPARATION AND CHARACTERISATION OF HYDROXYPROPYLATED CROSSLINKED SAGO STARCH FOR APPLICATION IN ACIDIC, FROZEN AND CANNED FOODS

SAOW AKON SUWANLIWONG

FSMB 1998 9



PREPARATION AND CHARACTERISATION OF HYDROXYPROPYLATED CROSSLINKED SAGO STARCH FOR APPLICATION IN ACIDIC, FROZEN AND CANNED FOODS

SAOWAKON SUWANLIWONG

MASTER OF SCIENCE UNIVERSITI PUTRA MALAYSIA

UPM BE

PREPARATION AND CHARACTERISATION OF HYDROXYPROPYLATED CROSSLINKED SAGO STARCH FOR APPLICATION IN ACIDIC, FROZEN AND CANNED FOODS

By

SAOWAKON SUWANLIWONG

October 1998



Dedicated to

My parents and my eldest sister

for their love,

understanding,

and encouragement

which have been a constant source of inspiration.



ACKNOWLEDGEMENTS

I would like to express my appreciation and gratitude to my supervisor, Dr. Sharifah Kharidah Syed Muhammad for her invaluable guidance, suggestions, constructive criticisms, and constant encouragement throughout the course of my study and in the dissertation preparation, and for the financial support. My deep appreciation and gratitude also go to Mr. Dzulkify Mat Hashim and Associate Professor Dr. Russly Abd Rahman for their support, invaluable guidance and suggestions.

I would like to thank the Dean and all the members of the Faculty of Food Science and Biotechnology, UPM for providing the research facilities and technical assistance during the course of my study.

My sincere gratitude is also extended to Associate Professor Paiboon Thamaratvasik, the Dean of the Faculty of Agro-Industry, Prince of Songkla University, for his kind support and encouragement. Appreciation also goes to Prince of Songkla University, Ministry of University Affairs, Thailand for granting me the study leave.

I am also grateful for the contribution from Ajinomoto Co.Ltd. and National Starch (M) Co.Ltd. Special thanks to my friends in the Starch Research Group,



Malini S., Faridah H., and Feri K. for their kind assistance, suggestions and encouragement.

I am greatly indebted to my beloved parents, sisters and brothers for their loving support. I wish to express my deepest appreciation to Mr. Chaiyawan Wattanachant for his support and encouragement. Finally, I would like to thank all my friends who gave me the needed encouragement during my study.



TABLE OF CONTENTS

		Page
ACKNOV	VLEDGEMENTS	ii
LIST OF	TABLES	i
LIST OF	FIGURES	хi
	PLATES	XV
	CT	
		xv
ABSTRAI	K	xix
CHAPTE	R	
I	GENERAL INTRODUCTION	
II	LITERATURE REVIEW	4
	StarchSources of Starch	2
	Structure of Starch	•
	Functions of Starch in Foods	9
	Sago Starch.	1:
	Production of Sago StarchQuality of Sago Starch	1: 10
	Physicochemical Properties of Sago Starch	19
	Utilisation of Sago Starch	2
	Modified Starch	2
	Crosslinked Starch	2:
	Substituted Starch	2
	Starch Phosphates	20
	Dual-Modification	2'
	Reaction Condition for Dual-modification	30
	Starch Base Concentration	3
	Alkaline Metal Salt	3
	Reaction pH	3:
	Reagents and Concentration	3
	Temperature and Time of Reaction	3:
	Purification and Recovery of Starch	3



	Control Measures
III	SUITABILITY OF SAGO STARCH AS A BASE FOR DUAL-MODIFICATION
	Introduction
	Materials and Methods. Proximate Analyses. Pasting Characteristics. Swelling Power. Paste Clarity.
	Results and Discussion. Quality of Native Sago Starch. Physicochemical Properties of Native Sago Starch. Pasting Characteristics of Native Sago Starch. Starch Base Properties Influencing the Dual-Modification.
	Conclusions
IV	PREPARATION AND CHARACTERISATION OF HYDROXYPROPYLATED CROSSLINKED SAGO STARCH.
	Introduction
	Materials and Methods
	Phosphorus Oxychloride
	Results and Discussion. Effects of Crosslinking Reagents on Dual-modified Sago Starch Properties. Effects of Propylene Oxide and Phosphorus
	Oxychloride Levels on Physicochemical Properties of Dual-Modified Sago Starch



	Optimum Propylene Oxide Level for	
	Dual-modification of Sago Starch	78
	Optimum Phosphorus Oxychloride Level for	
	Dual-modification of Sago Starch	81
	Effects of Hydroxypropylation Levels on	
	the Crosslinking with the Mixture of Phosphate Salts	83
	Conclusions	101
V	A COMPARISON OF HYDROXYPROPYLATED	
	CROSSLINKED SAGO STARCH WITH	
	COMMERCIALLY AVAILABLE MODIFIED	
	STARCHES FOR APPLICATION IN ACIDIC,	
	FROZEN AND CANNED FOODS	103
	Introduction	103
	Materials and Methods	104
	Preparation of Hydroxypropylated Crosslinked	
	Sago Starch	104
	Determination of Phosphorus Content	105
	Degree of Substitution and Molar Substitution	105
	Granule Morphology	105
	Pasting Characteristics	106
	Acid Stability	106
	Paste Clarity	106
	Sediment Volume	107
	Swelling Power and Solubility	107
	Freeze-Thaw Stability	107
	Gel Strength	108
	Statistical Analysis	108
	Results and Discussion	108
	Granule Morphology	108
	Chemical Control Measurement.	109
	Physical Characteristics	112
	Quality of Hydroxypropylated Crosslinked	
	Sago Starch	117
	Conclusions	123
VI	CANNING STABILITY OF HYDROXYPROPYLATED	
_	CROSSLINKED SAGO STARCH: TEXTURAL AND	
	RHEOLOGICAL ASPECTS	124
		124
	Introduction	124



	Materials and Methods Effect of Starch Concentrations and pHs of	126
	Canning Condition Effect of Sterilisation Time	127 127
	Viscosity Measurement	127
	Texture Measurement.	128
	Heat Penetration Determination.	128
	Statistical Analysis	129
	•	
	Results and Discussion	130
	Stability under Canning Condition	130
	Stability under Acidic Canning Condition	130
	Rheological Properties of HPST Starch Paste	132
	Texture Firmness of HPST Starch Paste	135
	Effect of Sterilisation Time	144
	Heat Penetration of HPST Starch Paste	148
	Conclusions	151
VII	GENERAL CONCLUSIONS AND	
	RECOMMENDATIONS	154
BIBLIOGRA	АРНУ	160
APPENDIX		
A	Analytical Methodology	166
В	Additional Figures	175
C	Additional Tables	178
VITAE		102



LIST OF TABLES

Γable		Page
1	Physicochemical Properties of Native Starches	10
2	Characteristics of Gelatinised and Cooled Starch Dispersions	11
3	Requirement Properties for Edible Sago Starch	18
4	Quality of Native Sago Starch Compared with SIRIM Standard (1992)	43
5	Physicochemical Properties of Native Starches	43
6	Properties of Hydroxypropylated Crosslinked Starch from General Starch Bases	48
7	Effects of Crosslinking Reagents on Pasting Properties of Hydroxypropylated Crosslinked Sago Starches	62
8	Effects of Crosslinking Reagents on Pasting Characteristics of Dual-Modified Sago Starch at the Condition of 6% Starch Solid, pH 6.5.	66
9	Effects of Crosslinking Reagents on Pasting Characteristics of Dual-Modified Sago Starch at the Condition of 6% Starch Solid, pH 3.5	70
10	F Values of Analysis of Variance for Physicochemical Properties of Dual-Modified Sago Starches Prepared using Different Levels of Propylene Oxide and Phosphorus Oxychloride	75
11	Effects of Propylene Oxide Level on Physicochemical Properties of Dual- Modified Sago Starches	7 9
12	Effects of Phosphorus Oxychloride Level on Physicochemical Properties of Dual-Modified Sago Starches	82
13	Physicochemical Properties of Native and Dual-Modified Sago Starches Hydroxypropylated with Different Levels of Propylene Oxide and Crosslinked with the Mixture of Phosphate Salts	84



14	Dual-Modified Sago Starches Hydroxypropylation with Different Levels of Propylene Oxide and Crosslinked with a Mixture of Phosphate Salts	90
15	Pasting Characteristic at 6% Starch Solid pH 6.5 of Native and Dual-Modified Sago Starches Hydroxypropylation with Different Levels of Propylene Oxide Crosslinked with the Mixture of Phosphate Salts.	93
16	Physicochemical Properties of Hydroxypropylated Crosslinked Sago Starch and Commercially Available Modified Starches for Application in Canned, High Acid and Frozen Foods	114
17	Pasting Characteristic of Hydroxypropylated Crosslinked Sago Starch and Commercially Available Modified Starches for Application in Canned, High Acid and Frozen Foods	116
18	Pasting Characteristics of Hydroxypropylated Crosslinked Sago Starch and Commercial Hydroxypropylated Crosslinked Tapioca Starch at Different pH Conditions	120
19	Some Properties of Hydroxypropylated Crosslinked Sago Starch and Commercial Hydroxypropylated Crosslinked Tapioca Starch	120
20	Canning Stability of Hydroxypropylated Crosslinked Sago Starch Paste at 6.5 pH.	131
21	Canning Stability of Hydroxypropylated Crosslinked Sago Starch Paste at 3.5 pH.	131
22	Effects of Starch Concentration on the Canning Stability of Starch Pastes at Different pH Conditions	134
23	Effect of Starch Concentrations on Flow Behaviour and Consistency Index of HPST	137
24	Linear Regression of HPST Firmness under Different pH Conditions before and after Canning.	139
25	F Value of Analysis of Variance for Texture Firmness of Hydroxypropylated Crosslinked Sago Starch Paste Influenced by Starch Solid, Paste Age and Canning	140



26	Effect of Canning on Texture of Hydroxypropylated Crosslinked Sago Starch Paste in 10% Sucrose at pH 6.5	145
27	Effect of Canning on Texture of Hydroxypropylated Crosslinked Sago Starch Paste in 10% Sucrose at pH 3.5	145
28	Effect of Sterilisation Times on Flow Behaviour and Consistency Index of HPST	147
29	Effects of Propylene Oxide Level and Storage Temperature on Gel Strength of Hydroxypropylated Crosslinked Sago Starch	178
30	Duncan's Multiple Range Test for Gel Strength Variable of Hydroxypropylated Crosslinked Sago Starch	178
31	Types of Commercial Modified Starches	179
32	Paste Properties of Commercial Modified Starches	180
33	Pasting Characteristic of Commercial Modified Starches at the Condition of 6.0% Starch Solid, pH 6.5	181
34	Pasting Characteristic of Commercial Modified Starches at the Condition of 6.0% Starch Solid, pH 3.5	181
35	Heat Penetration Data of Hydroxypropylated Crosslinked Sago Starch Paste	182



LIST OF FIGURES

Figure		Page
1	Crosslinking to Reinforce a Starch Granule	24
2	Stabilisation to Prevent Retrogradation	25
3	Pasting Characteristics of Native Starches obtained using Brabender Amylograph	46
4	Amylograms of Native (NT) and Dual-Modified Sago Starch, at 6% Starch Solid pH 6.5, Hydroxypropylation with 8% Propylene Oxide, and Crosslinking with 0.075% POCl ₃ (HPPO), 0.075% Epichlorohydrin (HPEP), and a Mixture of 2% STMP and 5% STPP (HPST).	65
5	Amylograms of Native (NT) and Dual-Modified Sago Starch, at 6% Starch Solid pH 3.5, Hydroxypropylation with 8% Propylene Oxide, and Crosslinking with 0.075% POC13 (HPPO), 0.075% Epichlorohydrin (HPEP), and a Mixture of 2% STMP and 5% STPP (HPST).	69
6	Freeze-Thaw Stability of Native and Dual-Modified Sago Starches	72
7	Effects of Propylene Oxide (PO) and Phosphorus Oxychloride (POCl ₃) Levels on Paste Clarity of Dual-Modified Sago Starches	77
8	Linear Regression of Swelling Power of Dual-Modified Sago Starches Hydroxypropylated with Different Levels of Propylene Oxide and Crosslinked with a Mixture of Phosphate Salts	86
9	Amylograms of Native (NT) and Dual-Modified Sago Starch at 6% Starch Solid, pH 6.5, Hydroxypropylation with 6%-12% Propylene Oxide, and Crosslinking with a Mixture of 2% STMP and 5% STPP.	89
10	Amylograms of Native (NT) and Dual-Modified Sago Starch at 6% Starch Solid, pH 3.5, Hydroxypropylation with 6%-12% Propylene Oxide, and Crosslinking with a Mixture of 2% STMP and 5% STPP.	97
	a MIALUIN DI 470 M LIVII AUU 370 M L F	4



11	Effect of Propylene Oxide Levels on Gel Strength of Dual-Modified Sago Starches Hydroxypropylated with 6-12% Propylene oxide Followed By Crosslinking with the Mixture of 2% STMP and 5% STPP.	95
12	Freeze-Thaw Stability of Native and Dual-Modified Sago Starches at Different Levels of Propylene Oxide	100
13	Amylograms of Hydroxypropylated Crosslinked Sago Starch (HPST) and Hydroxypropylated Crosslinked Tapioca Starch (NAT 8) at 6% Starch Solid, pH 6.5 (A) and pH 3.5 (B)	118
14	Swelling Power of Native (NT), Hydroxypropylated Crosslinked Sago Starch (HPST) and Hydroxypropylated Crosslinked Tapioca Starch (NAT 8)	121
15	Solubility of Native (NT), Hydroxypropylated Crosslinked Sago Starch (HPST) and Hydroxypropylated Crosslinked Tapioca Starch (NAT 8).	121
16	Freeze-Thaw Stability of Native (NT), Hydroxypropylated Crosslinked Sago Starch (HPST) and Hydroxypropylated Crosslinked Tapioca Starch (NAT 8)	122
17	Load-Penetration Curves for Paste of 5-7% HPST in 10% Sucrose at pH 3.5 before Canning	133
18	Load-Penetration Curves for Paste of 5-7% HPST in 10% Sucrose at pH 3.5 after Canning	133
19	The Flow Curve of HPST Starch Paste Viscosity (5-7% Starch Solid) in 10% Sucrose at pH 6.5, as affected by retorting at 15 psig for 30 min.	136
20	Firmness of HPST Starch Paste aged 48 hr at 25°C before and after Canning in 10% Sucrose at pH 6.5 and 3.5	139
21	Effect of Aging Paste of 5-7% hydroxypropylated Crosslinked Sago Starch Solid in 10% Sucrose at pH 6.5 and 3.5, before and after Canning on the Force at Maximum Deformation	142
22	Effect of Aging Paste of 5-7% hydroxypropylated Crosslinked Sago Starch Solid in 10% Sucrose at pH 6.5 and 3.5, before and after Canning on the Stickiness	143



23	Paste Viscosity	146
24	Effect of Sterilisation Times on Flow Behaviour Index Trend of HPST	147
25	Effect of Sterilisation Time on the Force at Maximum Deformation of HPST Starch Paste	149
26	Effect of Sterilisation Time on Stickiness of HPST Starch Paste	149
27	Heat Penetration Curve of Hydroxypropylated Crosslinked Sago Starch Paste	150
28	Standard Curve of Phosphorus Content	172
29	Standard Curve of Propylene Glycol	173
30	Amylograms of Commercial Modified Starches at 6% Starch Solid, pH 6.5	175
31	Amylograms of Commercial Modified Starches at 6% Starch Solid, pH 3.5	176
32	Effect of pH on Swelling Power of Native (NT) and Hydroxypropylated Crosslinked Sago Starch (HPST).	177



LIST OF PLATES

Plate		Page
1	Native and Dual-Modified Sago Starch Gels and Pastes at Different Hydroxypropylation Levels	97
2	Texture of Gel and Paste Property of the Native Sago and Hydroxypropylated Crosslinked Sago Starch with MS 0.033/DS 0.004	98
3	Granule Surface Appearance of Native Sago Starch at 200X (A) and 540X (B) Magnifications	110
4	Granule Surface Appearance of Hydroxypropylated Crosslinked Sago Starch at 200X (A) and 540X (B) Magnifications	111



Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master of Science

PREPARATION AND CHARACTERISATION
OF HYDROXYPROPYLATED CROSSLINKED SAGO STARCH
FOR APPLICATION IN ACIDIC, FROZEN AND CANNED FOODS

By

SAOWAKON SUWANLIWONG

October 1998

Chairman: Dr. Sharifah Kharidah Syed Muhammad

Faculty: Food Science and Biotechnology

Hydroxypropylation and crosslinking were carried out to improve the quality of sago starch. The optimum conditions for preparation of hydroxypropylated crosslinked sago starch were found to be an initial reaction with 10-12% propylene oxide at 40°C for 24 hr using 40% (dsb) starch slurry containing 15% sodium sulphate at pH 10.5. This was followed by crosslinking using a mixture of 2% sodium trimetaphosphate (STMP) and 5% sodium tripolyphosphate (STPP). Through hydroxypropylation, it was found that there was a significant increase in molar substitution which will in turn induce the increase in crosslinking and this was seen from the marked increase in phosphorus content and degree of substitution. This was accompanied by a significant decrease in paste clarity, swelling power and solubility compared to that of the native starch. The hydroxypropylated crosslinked



sago starch prepared also exhibited desirable properties in that it exhibited no viscosity breakdown, high acid resistance, high freeze-thaw stability and improved gel texture.

The hydroxypropylated crosslinked sago starch (HPST) was prepared in a larger scale having molar substitution (MS) and degree substitution (DS) values in the range of 0.038 to 0.045 and 0.004 to 0.005, respectively. The properties of HPST in terms of sediment volume, swelling power, solubility and paste clarity were 15.75%ml, 16.7, 8.62% and 5.18 %T₆₅₀, respectively. The MS value, phosphorus content, paste clarity, swelling power and syneresis after six freeze-thaw cycles of HPST when compared to that of commercially available modified starches which are normally used or incorporated in acidic, frozen and canned foods did not differ significantly. The pasting characteristic of HPST exhibited thin to thick viscosity which is similar (P>0.05) to that of commercial hydroxypropylated crosslinked tapioca starch (NAT 8). The acid stability, solubility and freeze-thaw stability of both starches were also similar (P>0.05) but the swelling power of HPST was slightly lower (P<0.05) than that of NAT 8.

The canning stability of HPST in terms of textural and rheological aspects was very high either in neutral or acidic canning condition at 15 psig (121°C) for 30 min. However, when sterilised longer than 40 min at 121°C, the HPST pastes (6% starch solid) experienced a significant decrease in viscosity and firmness. The HPST paste which consisted of 6% starch solid and 10% sucrose at pH 6.5 exhibited

rapid heat penetration. A sterilisation value (F_o) of 25.48 could be obtained from the sterilisation of HPST paste contained in a can size 300x305 at 121°C for 30 min.



Abstrak Tesis yang Dikemukakan kepada Senat Universiti Puta Malaysia Sebagai Memenuhi Keperluan untuk Ijazah Master Sains

PENYEDIAAN DAN CIRI-CIRI KANJI TERHIDROKSIPROPILASI-IKATAN SILANG UNTUK APLIKASI DALAM MAKANAN YANG BERASID, DIBEKUKAN DAN DALAM TIN

Oleh

SAOWAKON SUWANLIWONG

Oktober 1998

Pengerusi : Dr. Sharifah Kharidah Syed Muhammad

Fakulti : Sains Makanan dan Bioteknologi

Hidroksipropilasi dan ikat-silang telah dilakukan untuk meningkatkan kualiti kanji sagu. Didapati yang syarat optima untuk menyediakan kanji sedemikian adalah dengan memanaskan larutan kanji 40% (yang mengandungi natrium sulfat 15% dan pada pH 10.5) bersama 10-12% propylene oksida pada suhu 40°C, selama 24 jam. Ini diikuti dengan ikat-silang yang menggunakan campuran 2% natrium trimetaposfat (STMP) dan 5% natrium tripoliposfat (STPP). Melalui hidroksipropilasi, terdapat pertambahan penggantian molar yang bererti yang menggalakkan lagi ikat-silang; ini dapat dilihat melalui peningkatan kandungan fosforus dan kadar penggantian. Ini diikuti dengan penurunan bererti kejernihan pasta, kemampuan mengembang dan kelarutannya berbanding dengan kanji tempatan. Kanji terhidrosipropilasi dan terikat-silang yang dihasilkan juga berciri positif dalam erti kata stabil kelikatan, tahan asid, dan stabil masa "freeze-thaw".



Kanji sagu hidroksipropilasi-ikatan silang (HPST) yang berpenggantian molar (MS) antara 0.038 dan 0.045 serta darjah penggantian (DS) 0.004 dan 0.005 telah disediakan pada skala yang lebih besar. Ciri-ciri kanji HPST seperti isipadu sedimen, kemampuan mengembang, kelarutan dan kejernihan pasta adalah seperti berikut: 15.75%ml, 16.7, 8.62% dan 5.18%T₆₅₀. Didapati ciri-ciri HPST seperti: MS, kandungan fosforus, kejernihan pasta, kemampuan mengembang dan syneresis selepas enam pusingan freeze-thaw tidak berbeza secara bererti berbanding dengan kanji-kanji komersil yang banyak digunakan dalam makanan berasid, makanan beku dan makanan dalam tin. Pasta HPST menunjukkan ciri-ciri kelikatan dari yang cair hingga ke pekat adalah sama (p>0.05) dengan pasta kanji ubi kayu terhidrosipopilasi dan terikat silang (NAT 8). Juga sama (p>0.05) bagi kedua-dua kanji ialah kestabilan asid, kelarutan dan kestabilan freeze-thaw; bagaimana pun, kemampuan mengembang HPST adalah rendah sedikit (p>0.05) berbanding dengan kemampuan NAT 8.

Dari aspek tekstur dan rheologi, kestabilan kanji sagu hidroksipropilasi-ikat silang yang ditinkan mempamerkan kestabilan yang tinggi sama ada ditinkan dalam keadaan neutral mau pun dalam keadaan asidik pada 15psig (121°C), selama 30 minit. Bagaimana pun, apabila disterilisasi melebihi 40 minit pada suhu 121°C, kelikatan dan kemantapan tekstur pasta HPST (6% pejal) berkurangan secara bererti. Pasta HPST yang terdiri daripada 6% kanji pejal dan gula 10% pada pH 6.5 menunjukkan penusukan haba yang cepat. Nilai sterilisasi (F₀) 25.48 boleh



diperolehi dengan mengsterilisasi pasta HPST dalam tin berukuran 300 x 305 selama 30 minit.



CHAPTER I

GENERAL INTRODUCTION

Sago starch is abundant in Malaysia which is the principle exporter to the world market (Zulpilip et al., 1991). Over the past five years, it was discussed as an inexpensive source of food in Southeast Asia (Stanton, 1993; Magda, 1993). Nowadays, the effort in improvement of sago starch production and starch quality has increased its utilisation as an economically viable feedstock for conversion to industrial sugars, a biomass source for starch hydrolysates and alcohol fermentation (Stanton, 1993; Wang et al., 1996; 1995; Pranamuda et al., 1995; Gorinstein et al., 1994; Haska and Ohta, 1993; Kim and Rhee, 1993). However, the inherent physicochemical properties of sago starch have limited its utilisation as a domestic starch thickener, stabiliser or texture modifier in foods such as starch-based canned products, sauces, custards, pie fillings and frozen desserts.

The disadvantage of the native sago starch is its granules swell with easy rupture during heating and shearing (Yatsuki, 1986; Takeda et al., 1989). Its gel has an undesirable texture and thus it could not be employed in foods that would be subjected to heat processing. Through chemical modifications, however, starches can be altered to increase its usefulness (BeMiller, 1997). Many chemical modifications have been used to convert natural starches to derivatives that exhibit



specific characteristics. In modern foods which are increasingly processed, a vast requirements are needed in the modified food starches (Richmond et al., 1996). Therefore, it is necessary for a starch to be modified by different methods such as substitution and crosslinking to increase its usefulness (Lopez, 1987). Hydroxypropylation and crosslinking are commercially used in dual-modification of starch. The benefits from these modifications are that crosslinking will reinforce starch granules resulting in them to be more resistant in acid, heat and shearing while hydroxypropylation will improve their freeze-thaw or cold-storage stability (Wurzburg, 1986; Tuschhoff, 1986).

The commercially available starch thickeners that form a major part of the total starch sales to the food industry (Pomeranz, 1991) are mainly produced from waxy corn and tapioca. In Malaysia where sago starch is plentiful, food manufacturers have to spend a lot of money per year to import those starches in the native or modified forms to be used as thickeners. As reported in the Import and Export Trade Statistics, Malaysia in 1994 exported 8,413 tonne of sago starch valued at RM (Ringgit Malaysia) 5.6 million, but had to spend about RM 4.5 million for importing only 210 tonne of modified starches (Ahmad Zabri, 1996).

It is therefore the goal of this study to determine if sago starch could be used to substitute some commercially available modified starches by improving its properties through dual-modification: hydroxypropylation and crosslinking. It also aims to alter sago starch properties to be close to the characteristics of commercial starch thickeners being applied in acidic, frozen and canned foods. These foods

