



**Faculty of Engineering**

**Study on the Properties and Drying Kinetic Analysis of Sarawak Sago**

**Starch**

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# Study on the Properties and Drying Kinetic Analysis of Sarawak Sago Starch

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## DECLARATION

I declare that the work in the thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgments have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any degree.



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## ABSTRACT

The study covers the properties, drying kinetics, and drying models of Sarawak sago starch. Properties analyzed include the composition, morphology, size, color, viscosity, chemical bond and thermal stability. The properties were compared for sago starch produced from different sources. The first sample was the commercial sago flour, bought from Kota Samarahan supermarket, the second sample was lemantak, bought from local producer, which was prepared using traditional method, and the third sample was prepared in the laboratory. Effect of drying was analyzed using the sago starch that was prepared in the laboratory, dried using an oven at temperatures of 50 to 80°C and fan speed of 0 to 0.95 m/s, microwave at 200W, freeze dryer at -92°C, and sun drying. In addition, the effect of sample thickness of 0.5 to 2 cm, and different location within the oven was also assessed. For oven drying, sago starch was dried continuously and intermittently; continuous drying refers to drying without interruption, and for the intermittent drying, a drying schedule that involves switching the oven 'on' and 'off' for certain period. The drying models assessed were thin layer models of empirical concept, simplified Fickian model and Characteristic Drying Curve concept. Results show that there were differences in the measured properties for sago starch prepared using different methods. It was found that lemantak and starch prepared in the laboratory have quite similar properties, but quite significant differences observed for the commercial sago flour, which has lower in total starch content of 29.79%, resistant starch content of 8.19% , viscosity of 7.45% as well as broken granules. Drying at 60°C for 15 hours increased the whiteness and thermal stability and decreased the moisture content of the sago starch. Increase in whiteness was observed based on increment in whiteness index of 46.89%, while moisture content decrease of 75%. It was also found that the final

moisture content of samples dried intermittently was higher than those dried continuously, but below than 13%, which is considered within the quality required. The intermittent oven drying is considered more effective drying than continuous drying in terms of energy saving; the drying period for intermittent drying (10.8% at 12 hour) was almost similar with the period of continuous drying (9.2% at 12 hour). The use of fan was found to increase the drying process. It was observed that drying at lower temperature of 60°C with fan velocity of 1 m/s gives estimated diffusivity of  $5.77 \times 10^{-9} \text{ m}^2/\text{s}$ , which is higher than that observed for drying at 80°C without fan gives estimated diffusivity of  $1.27 \times 10^{-9} \text{ m}^2/\text{s}$ , suggesting that drying at lower temperature with added fan can be a good option for drying starch. It was also found that lower sample thickness results in faster drying. The diffusivity for sample thickness of 0.5 cm was estimated to be about  $8.2 \times 10^{-10} \text{ m}^2/\text{s}$ , which is 200% higher than that estimated for sample thickness of 2 cm with diffusivity of  $2.5 \times 10^{-9} \text{ m}^2/\text{s}$ . Meanwhile, the sample position within the oven showed insignificant drying effect. Most drying models able to illustrate the drying kinetics of starch satisfactorily except drying characteristics curve model. The empirical model gives the lowest standard error of 0.006. The fitted parameters for drying at 50 to 80 °C were drying constant estimated between 0.043 to 0.225, diffusivity between from  $7.086 \times 10^{-10}$  to  $1.268 \times 10^{-9} \text{ m}^2/\text{s}$  and activation energy of 17.7 to 19.4 kJ/mol.

**Keywords:** Sago starch, starch properties, drying kinetic, drying profile and model fitting

## ***Kajian terhadap Ciri-ciri Semulajadi dan Kinetik Pengeringan Kanji Sagu Sarawak***

### **ABSTRAK**

*Kajian ini meliputi sifat, kinetik pengeringan, dan model pengeringan pati sagu Sarawak. Sifat yang dianalisis termasuk komposisi, morfologi, saiz, warna, kelikatan, ikatan kimia dan kestabilan terma. Analisis sifat pati sagu yang dihasilkan daripada sumber yang berbeza juga termasuk proses tradisional pati sagu (lemantak), tepung sagu komersial, dan pati sagu basah yang diproses secara makmal. Eksperimen pengeringan lanjut melibatkan kanji sagu basah yang diproses di makmal yang telah dikeringkan menggunakan kaedah berbeza termasuk pengeringan ketuhar berterusan, pengeringan ketuhar terus-sekejap, pengeringan matahari, pengeringan gelombang mikro dan pengeringan beku. Untuk pengeringan ketuhar, suhu yang digunakan adalah antara 50 hingga 80°C, kelajuan kipas 0 hingga 0.95 m/s, ketuhar gelombang mikro pada gelombang 200W, pengeringan beku dan pengeringan matahari. Sebagai tambahan, ketebalan sampel 0.5 hingga 2 cm, dan lokasi yang berbeza di dalam ketuhar juga dianalisa menggunakan eksperimen pengeringan ketuhar. Untuk pengeringan berterusan, kanji dikeringkan secara berterusan tanpa gangguan. Manakala untuk pengeringan sekejap-sekejap, jadual pengeringan melibatkan pensuisan 'hidup' dan 'mati' ketuhar. Model pengeringan yang dinilai adalah model lapisan nipis konsep empirikal, model Fickian dipermudahkan dan konsep Lengkung Pengeringan Ciri. Keputusan menunjukkan bahawa kaedah pemprosesan kanji sagu mempengaruhi sifat kanji sagu. Didapati kanji komersial mempunyai jumlah kandungan kanji yang lebih rendah iaitu 29.79%, kandungan kanji tahan 8.19%, kelikatan 7.45% serta butiran pecah berbanding kanji yang disediakan di makmal. Selain itu, pengeringan pada suhu 60°C selama 15 jam menunjukkan peningkatan keputihan dan kestabilan terma, serta penurunan*

kandungan lembapan. Peningkatan keputihan diperhatikan berdasarkan kenaikan indeks keputihan sebanyak 46.89%, manakala kandungan lembapan menurun sebanyak 75%. Ia juga didapati bahawa kandungan lembapan akhir sampel yang dikeringkan secara berselang-seli adalah lebih tinggi daripada yang dikeringkan secara berterusan, tetapi di bawah 13%, yang dianggap dalam kualiti yang diperlukan. Pengeringan ketuhar sekejap dianggap pengeringan yang lebih berkesan daripada pengeringan berterusan dari segi penjimatan tenaga; tempoh pengeringan untuk pengeringan sekejap (10.8% pada 12 jam) adalah hampir sama dengan tempoh pengeringan berterusan (9.2% pada 12 jam). Juga didapati bahawa keresapan pengeringan pada 60°C dengan halaju kipas 1 m/s ( $5.77 \times 10^{-9}$  m<sup>2</sup>/s) adalah lebih tinggi berbanding dengan pengeringan pada 80°C ( $1.27 \times 10^{-9}$  m<sup>2</sup>/s), mencadangkan pengeringan pada suhu yang lebih rendah dengan kipas tambahan boleh menjadi pilihan yang baik untuk mengeringkan kanji. Ketebalan sampel yang lebih rendah menghasilkan pengeringan yang lebih cepat; pemerhatian menunjukkan peningkatan difusi sebanyak 200% untuk ketebalan sampel daripada 2 cm ( $8.2 \times 10^{-10}$  m<sup>2</sup>/s) kepada 0.5 cm ( $2.5 \times 10^{-9}$  m<sup>2</sup>/s). Sementara itu, kedudukan sampel dalam ketuhar menunjukkan kesan pengeringan yang tidak ketara. Kebanyakan model pengeringan dapat menggambarkan kinetik pengeringan kanji dengan memuaskan dengan model empirikal memberikan ralat piawai terendah iaitu 0.006, kecuali model lengkung ciri pengeringan. Parameter yang dipasang untuk pengeringan pada 50 hingga 80 °C ialah pemalar pengeringan yang diperolehi antara 0.043 hingga 0.225, keresapan antara  $7.086 \times 10^{-10}$  hingga  $1.268 \times 10^{-9}$  m<sup>2</sup>/s dan pengaktifan 17.7 hingga 19.4 kJ/mol.

**Kata kunci:** Kanji sagu, sifat kanji, kinetik pengeringan, profil pengeringan dan pemasangan model



## TABLE OF CONTENTS

	<b>Page</b>
<b>DECLARATION</b>	i
<b>ACKNOWLEDGEMENT</b>	ii
<b>ABSTRACT</b>	iii
<b><i>ABSTRAK</i></b>	v
<b>TABLE OF CONTENTS</b>	vii
<b>LIST OF TABLES</b>	xiv
<b>LIST OF FIGURES</b>	xvi
<b>LIST OF ABBREVIATIONS</b>	xxii
<b>LIST OF SYMBOLS AND UNITS</b>	xxiv
<b>CHAPTER 1: INTRODUCTION</b>	1
1.1 Background	1
1.1.1 The Importance of Sago Starch Industry in Malaysia	1
1.1.2 The Differences between Lemantak and Sago Flour	4
1.1.3 Drying Process	6
1.2 Problem Statement	8
1.3 Gap of Research	10

1.4	Research Objective	11
1.5	Research Questions	12
1.6	Hypothesis	12
1.7	Scope of Research and Its Limitations	13
1.8	Research Novelty	13
<b>CHAPTER 2: LITERATURE REVIEW</b>		15
2.1	Sago Palm and Its Significance	15
2.2	Sago Starch and Its Beneficial	17
2.3	Analysis on Starch Properties	19
2.4	Effect of Drying on Starch Properties	27
2.5	Effect of Drying on Starch Drying Characteristics	29
2.6	Drying Models for Starch	30
2.6.1	Empirical models	31
2.6.2	Fickian Diffusion models	35
2.6.3	Characteristic Drying Curve	39
2.6.4	Models for estimating the diffusivity	41
2.7	Summary of Literature Review and Research Gap	42
<b>CHAPTER 3: METHODOLOGY</b>		43
3.1	Sample Preparation	45

3.1.1	Sago Flour	45
3.1.2	Lemantak	46
3.1.3	Fresh sago starch	46
3.2	Characterization of Starch Properties	48
3.2.1	Chemical Properties	48
3.2.2	Moisture content	48
3.1.3.1	Amylose Content	49
3.1.3.2	Protein Content	49
3.1.3.3	Lipid content	50
3.1.3.4	Ash Content	51
3.2.3	Resistant Starch Content	51
3.2.4	Granules Morphology	52
3.2.5	Particle Size Distribution	52
3.2.6	Color	52
3.2.7	Peak Viscosity	54
3.2.8	Molecular characterization	54
3.2.9	Thermal Stability	55
3.2.10	Statistical Analysis of the Results	55
3.3	Drying Experiment	55

3.1.4	Oven drying	56
3.1.5	Sun Drying	59
3.1.6	Microwave Drying	59
3.1.7	Freeze Drying	60
3.4	Drying Kinetic Analysis	61
<b>CHAPTER 4: RESULTS AND DISCUSSION</b>		63
4.1	Introduction	63
4.2	Characterization of Processed Sago Starch	63
4.2.1	Chemical Properties of Sago Starch Samples	64
4.1.1.1	Moisture Content	64
4.1.1.2	Starch Content	65
4.1.1.3	Amylose Content	66
4.1.1.4	Fat Content	66
4.1.1.5	Protein Content	67
4.1.1.6	Ash Content	68
4.2.2	Resistant Starch Content of Sago Starch Samples	68
4.2.3	Granule Morphology of Sago Starch Samples	70
4.2.4	Particle Size Distribution of Sago Starch Samples	76
4.2.5	Color Analysis of Sago Starch Samples	78

4.2.6	Peak Viscosity of Sago Starch Samples	80
4.2.7	Molecular Characterization of Sago Starch Samples	81
4.2.8	Thermal Stability Analysis of Sago Starch Samples	83
4.2.9	Concluding Remarks	85
4.3	Effect of Drying on Sago Starch Properties	85
4.3.1	Effect of Drying on Sago Starch Moisture Content	85
4.3.2	Effect of Drying on Sago Starch Morphology	87
4.3.3	Effect of Drying on Sago Starch Granule Size	89
4.3.4	Effect of Drying on Sago Starch Color	92
4.3.5	Effect of Drying on Sago Starch Peak Viscosity	97
4.3.6	Effect of Drying on Sago Starch Molecular Characterization	100
4.3.7	Effect of Drying on Sago Starch Thermal Stability	102
4.3.8	Concluding Remarks	103
4.4	Effect of Drying on Sago Starch Final Moisture Content	104
4.4.1	Effect of Drying Temperature on Sago Starch Final Moisture Content	104
4.4.2	Effect of Air Velocity on Sago Starch Final Moisture Content	106
4.4.3	Effect of Sample Thickness on Sago Starch Final Moisture Content	108
4.4.4	Effect of Sample Position on Sago Starch Final Moisture Content	110
4.4.5	Effect of Drying Method on Sago Starch Final Moisture Content	111

4.4.6	Concluding Remarks	112
4.5	Drying Kinetic of Sago Starch	113
4.5.1	Effect of Drying Temperature to Sago Starch Drying Kinetic	113
4.5.2	Effect of Air Velocity to Sago Starch Drying Kinetic	116
4.5.3	Effect of Sample Thickness to Sago Starch Drying Kinetic	117
4.5.4	Effect of Sample Position to Sago Starch Drying Kinetic	119
4.5.5	Effect of Drying Methods to Sago Starch Drying Kinetic	121
4.5.6	Concluding Remarks	125
4.6	Moisture Diffusivities of Sago Starch	126
4.6.1	Sago Starch Moisture Diffusivities for Different Drying Temperatures	126
4.6.2	Sago Starch Moisture Diffusivities for Different Air Velocity	127
4.6.3	Sago Starch Moisture Diffusivities for different Sample Thickness	128
4.6.4	Sago Starch Moisture Diffusivities for different Drying Methods	129
4.6.5	Concluding Remarks	132
4.7	Assessment of Drying Model for Sago Starch	132
4.7.1	Assessment of Empirical Model for Sago Starch Drying Kinetic	132
4.7.1.1	Effect of Drying Temperature to Sago Starch`s Empirical Model Assessment	132
4.7.1.2	Effect of Drying Method to Sago Starch`s Empirical Model Assessment	137
4.7.2	Assessment of Simplified Fick Diffusion Model for Sago Starch Drying Kinetic	146

4.7.3	Assessment of Characteristic Drying Curve for Sago Starch Drying Kinetic	149
4.7.4	Concluding Remarks	153
<b>CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS</b>		<b>154</b>
5.1	Conclusions	154
5.2	Recommendations	156
5.2.1	Characterization	156
5.2.2	Kinetics	156
<b>REFERENCES</b>		<b>157</b>
<b>APPENDICES</b>		<b>178</b>

## LIST OF TABLES

	<b>Page</b>
Table 1.1 Annual sago production from Indonesia, Malaysia, and Papua New Guinea as the world`s top sago producer (M.A. Trisia et al., 2021)	2
Table 1.2 Income generated by Sarawak from sago exports	3
Table 1.3 The requirement from Malaysia Standard for edible and non-edible starch (Karim et al., 2008)	9
Table 2.1 Previous research findings on starch physicochemical properties	20
Table 2.2 Empirical models for fruit drying, Togrul and Pehlivan (2004)	32
Table 2.3 Empirical models for banana drying (Dandamrongrak et al. 2002)	36
Table 4.1 Chemical composition of sago starch from different processing methods	67
Table 4.2 Resistant starch value of lemantak, sago flour and fresh sago	72
Table 4.3 Color Properties of lemantak, sago flour and fresh sago starch	81
Table 4.4 Peak viscosity of lemantak, sago flour and fresh sago starch	83
Table 4.5 Granule size distribution analysis of sago starch at different moisture contents	94
Table 4.6 Color analysis for Hunter L*, a*, b* and whiteness index of sago starch at different moisture content.	98
Table 4.7 Peak Viscosity of sago starch at different moisture content	102



Table 4.8	Results of fitting model criteria; drying constants, Standard Error (SE) and correlation coefficient (R2) from different sago starch drying temperature	139
Table 4.9	Results of fitting model criteria; drying constants, standard error (SE) and correlation coefficient (R2) from different sago starch drying method	144
Table 4.10	Standard error (SE), correlation coefficient and drying constant results	155

## LIST OF FIGURES

		<b>Page</b>
Figure 2.1	Sago Palm Plantation Area in Mukah, Sarawak (WhyeKit et. al., 2019)	16
Figure 2.2	Structure of amylose, (a) and amylopectin (b) in starch (Tester et al., 2004)	18
Figure 3.1	Experimental design for the study on properties and drying kinetic properties of Sarawak sago starch.	46
Figure 3.2	Samples used for starch characterization. (a) Sago flour (b) Lemantak (c) Fresh sago starch	48
Figure 3.3	IKA® MF10 basic to grind sago log into sawdust	50
Figure 3.4	Step for extracting sago starch	51
Figure 3.5	Steps for measuring sago starch color (P. Koleda, 2019)	56
Figure 3.6	Location of sample inside drying oven	60
Figure 3.7	Sago sample in a tube	64
Figure 4.1	Starch granule in lemantak at 500 magnification	73
Figure 4.2	Starch granule in sago flour at 500 magnification	74
Figure 4.3	Starch granule in fresh sago starch at 500 magnification	75
Figure 4.4	Starch granule in lemantak at 2000 magnification	76

Figure 4.5	Starch granule in sago flour at 2000 magnification	77
Figure 4.6	Starch granule in fresh sago starch at 2000 magnification	78
Figure 4.7	Granule size distribution of (a) lemantak, (b) sago flour and (c) fresh sago starch	79
Figure 4.8	Infrared spectroscopy of (a) lemantak, (b) sago flour, and (c) fresh sago starch	85
Figure 4.9	Weight loss for lemantak, sago flour and fresh sago starch	87
Figure 4.10	Drying profile of fresh sago starch dried in oven at 40 °C	90
Figure 4.11	MC40 granules at (a) 500x magnification and (b) 2000x magnification	91
Figure 4.12	MC30 granules at (a) 500x magnification and (b) 2000x magnification	91
Figure 4.13	MC20 granules at (a) 500x magnification and (b) 2000x magnification	92
Figure 4.14	MC10 granules at (a) 500x magnification and (b) 2000x magnification	92
Figure 4.15	Particle size distribution of sago starch samples at different moisture content in wet basis for granule at diameter of 0 - 15 $\mu$ m	94

Figure 4.16	Particle size distribution of sago starch samples at different moisture content in wet basis for granule at diameter of 15 - 80 $\mu$ m	95
Figure 4.17	Color analysis of sago starch samples at different moisture content	97
Figure 4.18	L value vs Moisture content, MC (w.b. %)	99
Figure 4.19	a value vs Moisture content, MC (w.b. %)	100
Figure 4.20	b value vs Moisture content, MC (w.b. %)	100
Figure 4.21	WI value vs Moisture content, MC (w.b. %)	101
Figure 4.22	Peak Viscosity (AU) vs Moisture content, MC (w.b. %)	103
Figure 4.23	FT-IR spectra of four different sago starch samples treated to different moisture content labelled as MC40, MC30, MC20 and MC10. The roman numeral labels refer to FT-IR main region for starch (i)O-H stretch; (ii)C-H stretch; (iii) fingerprint of glycosidic linkages; (iv) skeletal mode of pyranose rings (Kizil et al., 2002)	104
Figure 4.24	TGA of sago starch at different moisture content in wet basis formula. (a) MC40 (b) MC30 (c) MC20 (d) MC10	106
Figure 4.25	Temperature, T ( $^{\circ}$ C) versus Equilibrium Moisture Content, EMC (d.b)	109

Figure 4.26	Air velocity, $v$ (m/s) versus Equilibrium moisture content, EMC (d.b %) at 60°C	111
Figure 4.27	Thickness, $h$ (cm) versus Equilibrium Moisture Content, EMC (% d.b)	113
Figure 4.28	Equilibrium moisture content versus sample position during drying	115
Figure 4.29	EMC of samples from various drying methods	116
Figure 4.30	Sago starch moisture content at different drying temperature	128
Figure 4.31	Sago starch drying rate at different drying temperature	119
Figure 4.32	Moisture content at different fan setting	121
Figure 4.33	Drying rate at different air velocity	122
Figure 4.34	Moisture content at different sample thickness	124
Figure 4.35	Drying rate at different sample thickness	125
Figure 4.36	Moisture content at different sample position	126
Figure 4.37	Drying rate at different sample position	127
Figure 4.38	Drying curve of sago starch at different drying methods	128
Figure 4.39	Drying rate curve in different drying methods	131
Figure 4.40	Moisture diffusivities at different drying temperature	133
Figure 4.41	Moisture diffusivities at different air velocity	134

Figure 4.42	Moisture diffusivities at different sample thickness	135
Figure 4.43	Moisture diffusivities at different drying methods	136
Figure 4.44	Predicted and experimental moisture content of sago starch using Lewis model for 50, 60, 70 and 80 °C.	142
Figure 4.45	Comparison of experimental and predicted value of Lewis model	143
Figure 4.46	Predicted and experimental moisture content of sago starch using Midili & Kucuk model for microwave drying	147
Figure 4.47	Comparison of experiment and predicted value of Midili & Kucuk model for microwave drying of sago starch	148
Figure 4.48	Predicted and experimental moisture content of sago starch using Page model for intermittent and continuous drying at 60 °C	149
Figure 4.49	Comparison of actual and predicted value of Page model for intermittent and continuous drying of sago starch at 60°C	150
Figure 4.50	Predicted and experimental moisture content of sago starch using Verma model for sun drying	151
Figure 4.51	Comparison of actual and predicted value of Verma model for sun drying	151
Figure 4.52	Predicted and experimental moisture content of sago starch using Page model for freeze drying	152

Figure 4.53	Predicted and experimental moisture content of sago starch using Modified Henderson & Pabis model for freeze drying	153
Figure 4.54	Comparison of actual and predicted value of Page and Modified Henderson & Pabis model for freeze drying	154
Figure 4.55	Predicted and experimental moisture content of sago starch using Simplified Fickian model for 50, 60, 70 and 80 °C	156
Figure 4.56	Comparison of experimental and predicted data (moisture content) by Simplified Fickian model	157
Figure 4.57	The relative drying rate as a function of the characteristic moisture content for continuous drying of sago starch	158
Figure 4.58	The relative drying rate as a function of the characteristic moisture content for intermittent drying of sago starch	159
Figure 4.59	The relative drying rate as a function of the characteristic moisture content for sun drying of sago starch	159
Figure 4.60	The relative drying rate as a function of the characteristic moisture content for microwave drying of sago starch	160
Figure 4.61	The relative drying rate as a function of the characteristic moisture content for freeze drying of sago starch	160

## LIST OF ABBREVIATIONS

ASEAN	The Association of Southeast Asian Nations
AACC	American Association of Cereal Chemists
ACH	Air Changes per Hour
ANOVA	One-way Analysis of Variance
AOAC	Association of Official Analytical Chemists
ATR	Attenuated Total Reflectance
BU	Brabender Unit
CIE	Commission on Illumination
EMC	Equilibrium Moisture Content
FTIR	Fourier Transform Infrared Spectroscopy
NaHSO <sub>3</sub>	Sodium Hydrogen Sulphite
RGB	Red Green Blue
RS	Resistant Starch
SD	Standard Deviation
SE	Standard Error
SEM	Scanning Electron Microscope
SMEs	Small Medium Enterprises