Faculty of Engineering

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

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Doctor of Philosophy

2024

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A thesis submitted

In fulfillment of the requirements for the degree of Doctor of Philosophy

(Transport Process)

Faculty of Engineering

UNIVERSITI MALAYSIA SARAWAK

2024

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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Date: July 23, 2024

ACKNOWLEDGEMENT

I would like to take this opportunity to acknowledge my supervisor who have supported and shared her knowledge contributes to the completion of this thesis.

My sincere gratitude to my husband, parents and children for the advice and support given during my period of study.

Finally, I would like to thank everyone for making it possible for me to complete my studies. Thank you all.

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 60ºC with fan velocity of 1 m/s gives estimated diffusivity of 5.77 x10^{-9} m^2/s, which is higher than that observed for drying at 80°C without fan gives estimated diffusivity of 1.27x10^{-9} m^2/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 x 10^{-10} m^2/s, which is 200% higher than that estimated for sample thickness of 2 cm with diffusivity of 2.5 x 10^{-9} m^2/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 ºC were drying constant estimated between 0.043 to 0.225, diffusivity between from 7.086x10^{-10} to 1.268x10^{-9} m^2/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 x10-9 m2/s) adalah lebih tinggi berbanding dengan pengeringan pada 80°C (1.27x10-9 m2/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 x 10-10 m2/s) kepada 0.5 cm (2.5 x 10-9 m2/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 ºC ialah pemalar pengeringan yang diperolehi antara 0.043 hingga 0.225, keresapan antara 7.086x10-10 hingga 1.268x10-9 m2/s dan pengaktifan 17.7 hingga 19.4 kj/mol.*

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

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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
$NaHSO_3$	Natrium Hydrogen Sulphite
RGB	Red Green Blue
RS	Resistant Starch
SD	Standard Deviation
SE	Standard Error
SEM	Scanning Electron Microscope
SMEs	Small Medium Enterprises