UNIVERSITI PUTRA MALAYSIA

VARIATIONS OF REFLECTANCE WITH MOISTURE CONTENT IN SINGLE MAIZE KERNELS AND SPINACH LEAVES AT WAVELENGTH 300 nm TO 800 nm

AMIZADILLAH BINTI MD NORIMI

FS 2011 103

VARIATIONS OF REFLECTANCE WITH MOISTURE CONTENT IN SINGLE MAIZE KERNELS AND SPINACH LEAVES AT WAVELENGTH 300 nm TO 800 nm

By

AMIZADILLAH BINTI MD NORIMI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

DECEMBER 2011

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

VARIATIONS OF REFLECTANCE WITH MOISTURE CONTENT IN SINGLE MAIZE KERNELS AND SPINACH LEAVES AT WAVELENGTH 300 nm TO 800 nm

By

AMIZADILLAH BINTI MD NORIMI

December 2011

Chairman : Zulkifly Abbas, PhD

Faculty : Science

This research describes an optical fiber reflectance technique in determining the moisture content in single maize kernels and spinach leaves in wavelength region from 300 nm to 800 nm. The technique is a simple, fast, non-destructive and accurate way to establish the relationship between reflectance and moisture content of both samples. Spectral acquisitions were controlled using the Ocean Optic Spectra Suite operating software. Samples were illuminated by a light source that combines deuterium and tungsten halogen light sources in a single optical path. The Ocean Optic Spectroscopy system consists of an integrated set of seven 440 µm diameter fibers with six illumination fibers encircling one detection fiber. Spectral changes were related to changes in the apparent colour of maize kernels and spinach leaves as it was influenced by moisture content. The results suggest that the percentage of reflectance decreases with moisture content for both maize kernel and spinach leaves at all wavelengths. Lower values in moisture content will result in a slightly darker colour of both samples which in turn will reduce the percentage values of

reflectance. In this work, the actual moisture content was found by applying standard oven drying method whilst the Kubelka-Munk theory was used to characterize the scattering and absorption coefficients of single maize kernels and spinach leaves. The performance characteristics of the optical fiber technique for the determination of moisture content were presented in terms of accuracy, standard deviation, probability density function and tolerance. The relative error of the optical fiber technique to determine moisture content based on reflectance measurements were found to be as low as 0.037 at 590 nm for single maize kernels and 0.073 at 380 nm for spinach leaves.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

VARIASI PANTULAN DENGAN KANDUNGAN KELEMBAPAN DALAM BIJI JAGUNG DAN DAUN BAYAM PADA PANJANG GELOMBANG 300 nm HINGGA 800 nm.

Oleh

AMIZADILLAH BINTI MD NORIMI

Disember 2011

Pengerusi : Zulkifly Abbas, PhD

Fakulti : Sains

Penyelidikan ini menerangkan teknik pantulan gentian optik dalam menentukan kandungan lembapan dalam biji jagung dan daun bayam pada rantau panjang gelombang dari 300 nm hingga 800 nm. Teknik ini adalah cara yang mudah, cepat, dan tidak memusnahkan serta tepat untuk mewujudkan hubungan antara pantulan dan kandungan lembapan bagi kedua-dua sampel. Pemerolehan spectrum telah dikawal dengan menggunakan sistem operasi Ocean Optic Spectra Suite. Sampel telah dicahayakan dengan cahaya yang menggabungkan sumber cahaya tungsten dan halogen pada laluan optic tunggal. Sistem spektroskopi Ocean Optic terdiri daripada set bersepadu tujuh gentian yang berdiameter 440 µm dengan enam gentian pencahayaan yang melingkungi satu gentian pengesan. Perubahan spektrum adalah berkait rapat dengan perubahan warna biji jagung dan daun bayam kerana ianye telah dipengaruhi oleh kandungan lembapan. Keputusan menunjukkan bahawa peratusan pantulan berkurang dengan kandungan lembapan bagi kedua-dua biji jagung dan daun bayam pada semua panjang gelombang. Nilai kelembapan yang sedikit rendah

akan menyebabkan warna kedua-dua sampel menjadi sedikit gelap dan seterusnya akan mengurangkan nilai peratusan pantulan. Dalam kerja ini, kandungan lembapan sebenar telah didapati dengan menggunakan kaedah pengeringan ketuhar biasa manakala Teori Kubelka-Munk digunakan untuk mendapatkan pekali penyebaran dan pekali penyerapan biji jagung dan daun bayam. Ciri-ciri prestasi teknik gentian optik bagi menetukan kandungan lembapan telah dibentangkan dari segi ketepatan, sisihan piawai, fungsi kebarangkalian ketumpatan dan toleransi. Ralat relatif teknik gentian optik untuk menentukan kandungan lembapan berdasarkan ukuran pantulan telah didapati serendah 0.037 pada 590 nm untuk biji jagung dan 0.073 pada 380 nm untuk daun bayam.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor Dr. Zulkifly Abbas for the continuous support of my Master study and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing this thesis.

Besides my supervisor, I would like to thank my co-supervisor Prof. Azmi Zakaria for his advice and supervision.

My sincere thanks also goes to all my fellow colleagues in RF and Microwaves Lab: Mohamad Ashry, Dr. Cheng Ee Meng, Farizah, Nor Zakiah, Rahimah, Mohd Aliff, Ahmad Fahad, Ali Hamad, and Faiz for their help and inspiring discussions, and for the great time we were working together.

Also I thank my best friends: Suryanti, Nurul Hazwani and Noorhanim for their encouragement, help and precious time we were spending together.

The special thanks goes to my family: my parents, for giving birth to me at the first place and supporting me spiritually throughout my life, my lovely sister and brothers and also my husband.

I certify that a Thesis Examination Committee has met on **29th Dicember 2011** to conduct the final examination of Amizadillah Binti Md Norimi on her thesis entitled "**Variations of Reflectance with Moisture Content in Single Maize Kernels and Spinach Leaves at Wavelength 300 nm to 800 nm**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P. U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of Master of Science.

Members of the thesis Examination Committee were as follows:

Lim Kean Pah, PhD
Lecturer
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Jumiah Hassan, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Khamirul Amin Matori, PhD
Lecturer
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Chandan Kumar Chakrabarty, PhD
Professor
Department of Electronics and Communication Engineering
Universiti Tenaga Nasional (UNITEN)
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Zulkifly Abbas, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Azmi Zakaria, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

AMIZADILLAH BINTI MD NORIMI

Date: 29 December 2011

TABLE OF CONTENTS