UNIVERSITI PUTRA MALAYSIA

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DAYANG NORULFAIRUZ BINTI ABANG ZAIDEL

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

December 2007

To my mother and father…

Thank you for your love and support.

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

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December 2007

Chairman : Chin Nyuk Ling, PhD

Faculty : Engineering

In this thesis, focus was given upon three factors affecting gluten production and development during dough mixing namely mixing time, salt levels and water levels. Gluten production was examined in terms of quantity and quality of gluten. Quantity of gluten was measured in terms of wet and dry gluten content. Wet gluten content was determined by weighing the gluten obtained from the dough washed under running tap water. The wet gluten was dried using air oven drying method to obtain dry gluten content. The quality of gluten was determined from the analysis of volume expansion, extensibility and rheological characterization. The volume expansion analysis was performed by frying the wet gluten in hot oil at 170^{o}C in deep fryer for 15 minutes. The volume of fried gluten was measured using mustard seed displacement method and the difference between the volume of fried gluten and the volume of wet gluten is measured as volume expansion of gluten.

The main problem encountered in performing gluten and dough extensibility test is to hold the sample so that it does not break at the jaws that hold the sample. Thus it is one of the objectives in this study to build a simple set-up of tensile test to determine gluten extensibility, which is one of the most common measurements employed in determining the quality of gluten. A simple set-up of tensile test which is attached to Instron 5566 has been build to determine gluten extensibility. Gluten strip of about 10 mm x 10 mm x 70 mm was clamped at two ends using plastic clips and extended at the centre by hook at speed of 300 mm min^{-1}. Extensibility parameters such as original gluten length, gluten length at fracture, measured force, actual force acting on the gluten strips, strain and stress were obtained using the formulas derived from the results of tensile test. The tensile test set-up was successful in terms of providing the gluten extensibility measurements and also the gluten did not fracture at the clamping area. Rheological characteristics of gluten, K and n, were obtained by fitting stress-strain curve following an exponential equation, $\sigma = Ke^{n\varepsilon}$. Two types of flour, strong and weak, were used as a comparison. Correlation between two analyses measurements of the gluten quantity and quality are determined at the end of this thesis.

An adequate polynomial equation model which fits the data was produced from Design Expert V.6.0.4. P-value, R^2 and lack-of-fit value were determined to verify the fitness of the polynomial model equation to the actual data and thus can be used as a good prediction of the data. The results from Design Expert were then transferred to Microsoft Excel file where the graph of the response was plotted against the three factors studied.

Results suggested that from the three factors studied, salt gave the most significant effect ($0.0001 < P < 0.02$) on the gluten quantity and quality. As salt level increases, it decreases the wet and dry gluten content. The volume expansion of gluten and the extensibility seem to decrease with increasing salt level. This indicates that gluten network strength reduces and it does not mix into elastic dough as salt level increases. The next significant factor was water level ($0.0001 < P < 0.67$). Mixing time was the least significant factor among the three ($0.0001 < P < 0.95$). For all factors studied, the results for strong flour were higher than the weak flour in the quantity, volume expansion and also extensibility. This demonstrates that the quality of gluten is affected by the protein content of the flour. All correlations between two analyses of quantity and quality measurements show positive coefficient of correlation (R). Strong correlation between (i) gluten quantity and volume expansion ($R > 0.75$), (ii) gluten quantity and extensibility ($R > 0.80$) and (iii) volume expansion and extensibility of gluten ($R > 0.60$) were obtained for strong flour compared to weak flour ($R > 0.45$; $R > 0.50$; $R > 0.30$, respectively). These results indicate that the quality of gluten is influenced by the protein content of the flour and the extensibility and volume expansion of gluten is positively correlated. These correlations could be used in the food industry to improve the gluten quantity and quality in the future.

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

FAKTOR – FAKTOR MEMPENGARUHI PENGHASILAN GLUTEN DAN SIFAT – SIFAT REOLOGINYA

Oleh

DAYANG NORULFAIRUZ BINTI ABANG ZAIDEL

Disember 2007

Pengerusi : Chin Nyuk Ling, PhD

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Dalam tesis ini, tumpuan diberikan kepada tiga faktor yang mempengaruhi penghasilan dan perkembangan gluten semasa pengadunan doh iaitu masa pengadunan, kandungan garam dan kandungan air. Penghasilan gluten ditentukan dari segi kuantiti dan kualiti gluten. Kuantiti gluten diukur dari segi kandungan basah dan kering gluten. Kandungan basah gluten diperolehi daripada doh yang dibasuh di bawah air paip yang mengalir. Gluten basah dikeringkan menggunakan kaedah pengeringan angin-ketuhar untuk memperoleh kandungan kering gluten. Kualiti gluten dinilai menerusi analisis pengembangan isipadu, kekenyalan dan sifat reologi. Pengembangan isipadu gluten dijalankan dengan menggoreng gluten di dalam minyak panas pada suhu 170^{o}C menggunakan periuk penggoreng selama 15 minit. Isipadu gluten yang digoreng ditentukan dengan menggunakan kaedah

sesaran biji sawi dan perbezaan di antara isipadu gluten yang digoreng dan gluten basah diambil sebagai pengembangan isipadu gluten.

Masalah utama yang dihadapi semasa menjalankan ujian kekenyalan doh dan gluten ialah bagi mengepit sampel supaya ia tidak putus pada kawasan pengepit. Oleh itu, salah satu daripada objektif tesis ini adalah untuk membina sebuah alat penguji tensil yang ringkas untuk menguji kekenyalan gluten, yang merupakan satu cara untuk menentukan kualiti gluten. Sebuah alat penguji tensil yang ringkas untuk dipasangkan kepada Instron 5566 telah dibina untuk menentukan kekenyalan gluten. Kepingan gluten yang berukuran 10 mm x 10 mm x 70 mm dikepit pada hujung kedua-dua belah menggunakan klip plastik dan ditarik di tengah-tengah dengan menggunakan cangkuk pada kelajuan 300 mm min^{-1}. Ukuran kekenyalan seperti panjang asal gluten, panjang gluten semasa putus, daya ukuran, daya sebenar bertindak pada gluten, tegangan dan regangan dikira dengan menggunakan rumus yang diperoleh melalui ujian tensil. Alat penguji tensil ini berjaya dari segi menghasilkan ukuran kekenyalan gluten dan juga gluten tidak putus pada kawasan apitan. Sifat reologi gluten, K dan n, diperolehi dengan memadankan lengkungan tegangan-regangan mengikut persamaan eksponensial, $\sigma = Ke^{n\varepsilon}$. Dua jenis tepung, kuat dan lemah, digunakan sebagai perbandingan. Korelasi antara dua ukuran bagi kuantiti dan kualiti gluten ditentukan di akhir kajian ini.

Model persamaan polinomial yang menepati data telah dihasilkan daripada Design Expert V.6.0.4. Nilai P, R^2 dan *lack-of-fit* ditentukan bagi mengesahkan kesesuaian model persamaan polinomial tersebut terhadap data sebenar dan seterusnya akan digunakan sebagai ramalan yang bagus untuk data tersebut. Keputusan daripada Design Expert kemudian dipindahkan ke fail Microsoft Excel di mana graf respon diplot melawan tiga faktor yang dikaji.

Keputusan menunjukkan di antara tiga faktor yang dikaji, garam memberikan kesan yang paling signifikan ($0.0001 < P < 0.02$) terhadap kuantiti dan kualiti gluten. Dengan peningkatan kandungan garam, ia mengurangkan kandungan basah dan kering gluten. Isipadu pengembangan dan kekenyalan gluten menurun dengan peningkatan kandungan garam. Ini menunjukkan bahawa kekuatan rangkaian gluten berkurangan dan ia tidak diadun menjadi doh yang kenyal apabila kandungan garam bertambah. Faktor yang signifikan berikutnya ialah kandungan air ($0.0001 < P < 0.67$). Masa pengadunan adalah faktor yang paling kurang signifikan di antara tiga faktor tersebut ($0.0001 < P < 0.95$). Untuk semua faktor yang dikaji, keputusan bagi jenis tepung yang kuat adalah lebih tinggi berbanding tepung yang lemah dari segi kuantiti, isipadu pengembangan dan juga kekenyalan. Ini menunjukkan bahawa kualiti gluten dipengaruhi oleh kandungan protin tepung. Semua korelasi di antara kuantiti dan kualiti menunjukkan nilai pekali hubungkait (R) yang positif. Korelasi yang tinggi di antara (i) kuantiti gluten dan pengembangan isipadu gluten ($R > 0.75$), (ii) kuantiti gluten dan kekenyalan gluten ($R > 0.80$) dan

(iii) pengembangan isipadu dan kekenyalan gluten ($R > 0.60$) diperolehi bagi tepung yang kuat dibandingkan dengan tepung yang lemah ($R > 0.45$; $R > 0.50$; $R > 0.30$, masing-masing). Keputusan ini menunjukkan bahawa kualiti gluten dipengaruhi oleh kandungan protin tepung dan kekenyalan dan pengembangan isipadu gluten adalah berkorelasi secara positif. Korelasi – korelasi ini boleh digunakan dalam industri makanan bagi meningkatkan kuantiti dan kualiti gluten pada masa hadapan.

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I certified that an Examination Committee has met on 18 December 2007 to conduct the final examination of Dayang Norulfairuz binti Abang Zaidel on her Master of Science thesis entitled "Factors Affecting Gluten Production and its Rheological Characterizations" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the student be awarded the degree of Master of Science.

Members of the Examination Committee were as follows:

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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:

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Date: 21 February 2008

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

DAYANG NORULFAIRUZ BINTI ABANG ZAIDEL

Date: 4 January 2008

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