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UNIVERSITI PUTRA MALAYSIA

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By

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Chairman : Chin Nyuk Ling, PhD

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The main objectives of this study are to investigate the effects of baking temperature, time and humidity on bread qualities and subsequently find the relationship between bread crust and crumb properties.

The bread samples were prepared following the straight-dough method. In determining crust and crumb, the difference in colour between these two regions was used. The colour of crust and crumb were measured using a chromameter. The colour range obtained for crust based on top crust colour of commercial bread samples is L <66.0, a > 2.4 and b >22.3 while crumb has a range of L >66.0, a <2.4 and b< 22.3. This colour range is used as a guideline in determining crust thickness of baked loaf samples. Bread slices were scanned to obtain its L a b values and the crust thickness was determined from the crumb region when the L a b values are met. The evaluation of crumb moisture content and firmness were conducted following the standard method of

American Association of Cereal Chemist (AACC) 14-5A and American Institute of Baking (AIB), respectively. Experimental results were statistically analyzed using Analysis of Variance (ANOVA).

Various combination of baking temperature, time and humidity affected the organoleptic properties of bread. Baking temperature and time significantly affect bread crust colour ($P<0.001$), thickness ($P<0.001$), initial moisture content ($P<0.05$) and firmness ($P<0.001$). Baking temperature has larger effect on crust colour and thickness compared to baking time. Higher baking temperature produced darker and thicker crust. Rate of thickness increment was also higher at high baking temperature (0.0465 mm/min) compared to low baking temperature (0.0085 mm/min). Increasing baking temperature produces crumb of high initial moisture content with high firmness value. The effect of baking time ($P<0.01$) is less significant than temperature however increasing baking time would also darken the crust colour and increases the thickness, increases crumb firmness and reduces crumb moisture content.

The application of humidified baking has no significant impact on crust coloration ($P>0.05$) however it causes a decrease in crust thickness ($P<0.05$), retain moisture ($P<0.01$) and reduce firmness ($P<0.05$). Humidified baking also reduces moisture migration ($P<0.01$) and firming rate ($P<0.01$) of breads during storage. Besides humidified baking, the usage of baking lid also have potential in increasing *L* and *b* values ($P<0.001$) and reducing *a* value and crust thickness ($P<0.001$). However, the

application of lid prevents bread expansion and causes high firmness value in bread. Sandwich bread has lower moisture content compared to open bread.

Three important correlations were obtained from the study that are between top crust colour difference (ΔE) and thickness, ΔE and firmness and finally crust thickness and firmness. The correlation between ΔE and thickness for non-humidified (NH) baking is represented by $y_{NH} = 0.1724x$ and $y_H = 0.1712x$ for humidified (H) baking. The coefficient of correlation, R^2, for correlation between ΔE and thickness for non-humidified baking and humidified baking are given by 0.9467 and 0.9341, respectively. A simple model of $T = k\Delta E$ derived from the correlation between ΔE and thickness indicates that the crust thickness (T) can be predicted by the changes in crust colour (ΔE). The heating constant, *k*, is dependant of baking temperature. The correlation, ΔE and firmness has the R^2 of 0.8306 for non-humidified baking and 0.8025 for humidified baking. The correlation between ΔE and firmness for non-humidified baking is represented by $y_{NH} = 0.8375x + 20.824$ and $y_H = 0.8127x + 25.035$ for humidified baking. The other correlation, thickness and firmness has the R^2 of 0.7436 and 0.6915, for non-humidified and humidified baking, respectively. The correlation of thickness and firmness for non-humidified baking is represented by $y_{NH} = 4.0385x + 26.952$ and $y_H = 3.921x + 30.852$ for humidified baking. The high value of R^2 shows that there is a strong relationship between colour, thickness and firmness. Crust colour can be used in predicting crust thickness and crumb firmness.

In conclusion, the results show that the bread crust and crumb properties are highly dependent of baking temperature and time. The moisture content and firmness in crumb are also affected by crust formation. This research also produces several significant contributions for bakery study; new method of measuring crust thickness using colour, humidified baking application for improving the storage quality of bread and finally establishment of correlations and linear model that can be used to estimate crust thickness and probably anticipate crumb behavior during storage.

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

KESAN SUHU, MASA DAN LEMBAPAN BAGI PEMBAKARAN KE ATAS SIFAT-SIFAT KERAK DAN ISI ROTI

Oleh

YANTI MASLINA MOHD. JUSOH

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Tujuan penyelidikan ini adalah untuk mengkaji kesan suhu, masa dan kelembapan ketika pembakaran ke atas kualiti roti dan seterusnya mendapatkan hubungan di antara kerak dan isi roti.

Sampel roti telah disediakan mengikut kaedah *straight-dough*. Perbezaan warna di antara kerak dan isi roti telah digunakan untuk membezakan kedua-dua bahagian ini. Ukuran ke atas warna kerak dan isi roti telah dilakukan menggunakan alat *chromameter***.** Dengan menggunakan sample roti komersial, julat warna bagi kerak dan isi roti telah ditetapkan yang mana bahagian kerak mempunyai julat warna $L<66.0$, $a>2.4$ dan $b>22.3$ dan bahagian isi roti mempunyai julat warna $L>66.0$, $a<2.4$ dan $b<22.3$. Julat warna yang diperolehi ini digunakan untuk mengukur ketebalan kerak roti. Kepingan

roti diimbas bagi mendapatkan nilai-nilai *L a b* dan seterusnya ketebalan kerak ditentukan apabila nilai-nilai *L a b* mencapai nilai julat warna bagi bahagian kerak roti. Kandungan lembapan dan kepadatan isi roti diukur berdasarkan kaedah piawai *American Association of Cereal Chemist* (AACC) 14-5A dan *American Institute of Baking (*AIB). Keputusan eksperimen telah dianalisa menggunakan *Analysis of Variance* (ANOVA).

Gabungan pelbagai suhu, masa dan kelembapan ketika pembakaran telah memberi kesan ke atas sifat-sifat roti. Masa and suhu memberikan kesan yang signifikan ke atas warna ($P<0.001$) dan ketebalan ($P<0.001$) kerak roti, lembapan awal ($P<0.05$) dan kepadatan isi roti ($P<0.001$). Suhu pembakaran mempunyai kesan yang lebih ketara ke atas warna dan ketebalan kerak roti berbanding masa pembakaran. Suhu pembakaran yang tinggi menyebabkan pembentukan kerak yang lebih gelap dan tebal. Kadar peningkatan ketebalan kerak berlaku dengan lebih pantas ketika suhu pembakaran tinggi (0.0465 mm/min) berbanding suhu yang rendah (0.0085 mm/min). Peningkatan suhu pembakaran menghasilkan isi roti berkelembapan awal yang tinggi dan meningkatkan kepadatannya. Kesan masa pembakaran ($P<0.01$) kurang signifikan berbanding suhu pembakaran, namun peningkatan masa pembakaran turut menghasilkan kerak yang lebih gelap dan tebal, meningkatkan kepadatan isi roti tetapi menurunkan kandungan lembapannya.

Aplikasi kelembapan ketika pembakaran tidak memberi kesan kepada warna kerak ($P>0.05$) namun ia menyebabkan pengurangan ketebalan kerak ($P>0.01$), mengekalkan

kelembapan (P<0.01) dan mengurangkan kepadtan (P<0.05) pada isi kerak. Kaedah ini juga mengurangkan kadar perpindahan lembapan (P<0.01) and kepadatan (P<0.01) pada isi roti ketika roti dalam penyimpanan. Selain daripada kaedah ini, penggunaan penutup acuan pembakaran juga berpotensi dalam meningkatkan nilai *L* dan *b* (P<0.001) dan mengurangkan nilai *a* dan ketebalan kerak roti (P<0.001). Namun, aplikasi penutup acuan pembakaran merencat pengembangan roti dan mengakibatkan nilai kepadatan yang tinggi pada roti. Roti *sandwich* mempunyai kandungan lembapan rendah berbanding roti *open.*

Tiga korelasi penting telah didapati dari kajian ini iaitu korelasi di antara perbezaan warna (ΔE) kerak dan ketebalan kerak, ΔE kerak dan kepadatan isi roti dan akhir sekali hubungan di antara ketebalan roti dan kepadatan isi roti. Korelasi di antara ΔE dan ketebalan kerak untuk pembakaran tanpa kelembapan (NH) diwakili oleh $y_{NH} = 0.1724x$ and $y_H = 0.1712x$ bagi pembakaran berkelembapan (H). Pekali korelasi, R^2 , bagi korelasi antara ΔE kerak dan ketebalan kerak untuk pembakaran tanpa kelembapan dan berkelembapan adalah 0.9467 dan 0.9341. Satu terbitan mudah $T = k\Delta E$ yang diperolehi daripada korelasi di antara ΔE kerak dan ketebalan kerak menunjukkan bahawa ketebalan kerak (T) boleh diunjurkan melalui perubahan warna pada bahagian kerak (ΔE). Pemalar pemanasan, *k*, bergantung kepada suhu pembakaran. Korelasi antara AE kerak dan kepadatan isi roti mempunyai R^2 0.8306 bagi pembakaran tanpa lembapan dan 0.8025 bagi pembakaran berkelembapan. Korelasi ini diwakili oleh $y_{NH} = 0.8375x + 20.824$ bagi bagi pembakaran tanpa lembapan (NH) dan $y_H = 0.8127x + 25.035$ bagi pembakaran berkelembapan (H). Korelasi penting yang lain ialah antara ketebalan

kerak dan kepadatan isi roti dengan nilai R^2 0.7436 dan 0.6915, bagi pembakaran tanpa kelembapan dan berkelembapan, masing-masing. Korelasi ini diwakili y_{NH} = 4.0385x + 26.952 bagi bagi pembakaran tanpa lembapan dan y_H = 3.921x + 30.852 bagi pembakaran berkelembapan. Nilai R^2 yang tinggi menunjukkan bahawa terdapat hubungan yang kuat antara warna, ketebalan kerak dan kepadatan isi roti. Warna kerak roti boleh digunakan untuk menganggar ketebalan kerak dan ketegangan isi roti.

Kesimpulannya, keputusan ujikaji menunjukkan bahawa sifat-sifat kerak dan isi roti adalah bergantung kepada suhu dan masa pembakaran. Kandungan kelembapan dan kepadatan isi roti dipengaruhi oleh proses pembentukan kerak roti. Pelbagai penemuan penting dalam bidang pembuatan bakeri telah dicapai melalui penyelidikan ini iaitu kaedah baru untuk mengukur ketebalan kerak roti menggunakan warna, penggunaan kelembapan dalam pembakaran bertujuan untuk memperbaiki kualiti penyimpanan roti dan penemuan terhadap beberapa korelasi dan model linear yang boleh digunakan untuk menganggarkan ketebalan dan perubahan sifat isi roti ketika dalam penyimpanan.

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I would like to end this segment with an encouraging thought by Arland Gilbert:

"When we accept tough jobs as a challenge to our ability and made into them with joy and enthusiasm, miracles can happen."

I certified that an examination committee has met on 30th June 2008 to conduct the final examination of Yanti Maslina bt. Mohd. Jusoh on her Master of Science thesis entitled "Effects of Baking Temperature, Time and Humidity on Bread Crust and Crumb Properties" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1990 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommended that the candidate be awarded relevant degree.

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

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Date: 11 September 2008

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.

YANTI MASLINA MOHD. JUSOH

Date : 20 August 2008

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LIST OF ABBREVIATIONS

ANOVA	analysis of variance
AVE	average
CLSM	confocal laser scanning microsope
DSC	differential scanning calorimetry
SEM	scanning electron microscope
STD DEV	standard deviation
STD ERR	standard error

CHAPTER 1

1 INTRODUCTION

1.1 An Overview on Bread in Malaysia

Bread is the second most popular staple food in Malaysia (Anon., 2007a). Bread industry in Malaysia has risen significantly throughout these years in parallel to the growing number of Malaysian population. The increasing bread sales trend of 4 % from year 2005 to year 2006 is a strong indicator that bread is a significant food in Malaysia's modern society. According to the Euromonitor 2007 market research report, the value of sales for bread in Malaysia is up to Ringgit Malaysia 636 millions in 2007 (Anon, 2007a). The changes in Malaysian society life-styles and an increase in population influence the Malaysians eating habit (Anon., 2006). Health awareness and busy lifestyles with the increasing cost of living contribute to the buoyant demand for bread in this country.

Bread is accepted as an important substitute for Malaysian staple food, rice, as it generally contains similar nutritional diet as rice in terms of its carbohydrate, protein and starch contents. It is also as filling as rice. Apart from its nutritional value and being a stomach filler, bread is also famous because it is easy to consume, and no additional dishes requires to compliment it. Besides that, bread can be fortified with functional ingredients that could benefit people health. Functional breads, where ordinary bread is combined with functional ingredients such as calcium, collagen, vitamins, fiber,