

PROCEEDING

**INTERNATIONAL SEMINAR ON FOOD AND
AGRICULTURAL SCIENCES-ISFAS2010**

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16-17 FEBRUARY 2010

HILL HOTEL AND CONVENTION, BUKITTINGGI-INDONESIA

Improving the quality of life through food and agricultural sciences

Jointly organized by:

Faculty of Agricultural Technology,
Universitas Andalas, Padang-Indonesia.

and

School of Chemical Sciences and Food Technology
Faculty of Science and Technology,
Universiti Kebangsaan Malaysia.

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Improving the quality of life through food and agricultural sciences

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Preface

Bismillahir-Rahmanir-Rahim,

Andalas University (UNAND) Padang, Indonesia, and Universiti Kebangsaan Malaysia have signed a letter of Memorandum of Understanding (MOU) on the 7th of March 2008. Both parties are interested in entering an MOU on education, teaching, research, academic and student exchange program. A joint seminar is among one of the academic activities proposed to be carried out from this MOU.

As a follow-up to the MoU, the School of Chemical Sciences & Food Technology, Faculty of Science and Technology (FST), UKM and Faculty of Agricultural Technology, UNAND, have agreed to conduct the 1st joint International Seminar on Food and Agricultural Sciences 2010 (ISFAS2010) on 16-17 February 2010 at Universitas Andalas, Padang, Indonesia. The objectives of seminar are:

1. To exchange and share experiences, new ideas and research findings
2. To promote research collaboration in improving the quality of life through natural resources-based science and technology.
3. To establish a regional network on food and agricultural sciences

This proceeding was developed as a result of ISFAS2010 seminar held on February 16-17, 2010 at the Hotel Hill Convention Center, Bukittinggi, INDONESIA. There were 141 papers presented in this ISFAS2010, consisting of 5 plenary papers, 63 papers for oral presentation and 73 papers for poster presentation. The papers were divided into 4 major topics covering topics on sustainable agriculture, chemical sciences and chemical engineering, food science and technology; biomass, bioenergy sources and management and industrial engineering.

We hope this proceeding could contribute to the role of higher education in developing food and agricultural sciences to improve the quality of life and welfare of mankind.

Bukittinggi, 17 February 2010

Novizar Nazir

Head of Programme and Proceeding

Welcoming address by the Chairman



In order to exchange and share experiences, new ideas and research findings, to promote research collaboration and network especially on natural resources-based sciences and technology between Universiti Kebangsaan Malaysia (UKM) and Universitas Andalas (UNAND), Padang, the two universities had agreed to conduct an International Seminar on Food and Agricultural Sciences which was called *ISFAS 2010*. The seminar was held in Bukittinggi on February 16-18, 2010, featuring papers for oral presentation and poster presentation. This opportunity was also used to sign the letter of Memorandum of Understanding (MoU) between Faculty of Science and Technology (FST) University, Malaysia and Faculty of Agricultural Technology, Andalas University, Padang. The series of activities was completed with a social work in Nagari Sicincin, one area badly suffering from the last year earthquake.

This seminar was attended by participants coming from Malaysia, Yemen, Libya, Japan and Indonesia. The papers or posters covered topics on sustainable agriculture, chemical sciences and chemical engineering, food science and technology, biomass, bio-energy sources and management and industrial engineering. This seminar presented Director General of Higher Education of Republik Indonesia as Keynote speaker and four plenary papers.

On this occasion, we would like to express our best gratitude to all members of organizing committee for working very hard in making this seminar happen. We also would like to praise the presenters for responding very enthusiastically to our call for paper. Last but not least, we would like to pay our best gratitude to the Rector of University of Andalas, the Vice Chancellor of Universiti of Kebangsaan Malaysia and Walikota Bukittinggi for supporting this seminar. We wish you all the best and hope you enjoy the seminar!

Thank you,

Prof. Dr. Anwar Kasim

Chairman of ISFAS2010

Kata Pembuka dari Dekan Fakultas Teknologi Pertanian Universitas Andalas



Seminar Internasional On Food and Agricultural Sciences 2010 (ISFAS 2010) adalah bagian dari tahapan kerjasama yang sudah dirintis antara Universitas Andalas (Unand) dengan Universiti Kebangsaan Malaysia (UKM). Pelaksanaan Seminar ini dimotori oleh Fakultas Teknologi Pertanian Unand bersama dengan Fakultas Sains dan Teknologi UKM. Bagi Fakultas Teknologi Pertanian Unand sendiri, seminar yang kita selenggarakan hari ini merupakan kado istimewa menjelang pelaksanaan Ulang Tahun ke dua fakultas ini.

Kami telah membaca dengan seksama bahwa makalah yang disampaikan dalam seminar ini adalah hasil penelitian yang dilakukan oleh para akademisi dan peneliti dari beberapa negara yang antara lain; Indonesia, Malaysia, Jepang dan Thailand. Disamping itu cakupan materi yang disampaikan juga sangat kompleks yang mencakup; Chemical Sciences and chemical Engineering, Food Sciences and Technology, Biomass, Bioenergy Sources and Management. Engineering and Industrial Process Engineering; Sustainable Agriculture. Dengan demikian apa yang disampaikan dalam seminar ini tentu akan menjadi inspirasi yang sangat besar terutama dalam mengkaji lebih dalam, mengembangkan serta memanfaatkan sumberdaya pertanian guna mensejahterkan kehidupan masyarakat di muka bumi ini.

Kami patut bersyukur melihat besarnya perhatian dan keinginan Bapak, Ibu serta Saudara para akademisi, peneliti dan praktisi untuk ikut serta berpartisipasi baik sebagai pemakalah maupun sebagai peserta pada seminar ini. Hal ini menunjukkan kesamaan persepsi dan keinginan kita untuk bertukar pikiran, menyampaikan hasil penelitian yang sudah dilakukan untuk dapat dimanfaatkan oleh orang banyak guna mensejahterkan kehidupan manusia. Lebih dari itu pertemuan banyak pihak dalam seminar ini diharapkan juga akan melahirkan jaringan kejasama yang lebih luas dengan melibatkan banyak pihak. Dengan demikian pekerjaan yang semula menjadi tugas masing-masing akan dapat dikolaborasikan menjadi tugas bersama, sehingga memberikan hasil dan manfaat yang lebih besar.

Akhirnya izinkanlah kami menyampaikan terima kasih yang sebesar-sebesarannya kepada yang mulia Rektor Universiti Kebangsaan Malaysia, Rektor Universitas Andalas, Dekan Fakultas Sains dan Teknologi UKM, Wali Kota Bukittinggi, Dinas dan Instansi Pemerintah dan swasta serta semua pihak yang tidak dapat kami sebutkan satu persatu yang telah berpartisipasi hingga terselenggaranya seminar ini dengan baik.

Kami menyadari sepenuhnya bahwa tidak ada kesempurnaan yang dapat kita capai, sehingga kekurangan masih akan kita temui disana sini. Untuk itu atas nama pimpinan fakultas kami menyampaikan maaf yang sebesar-besarnya atas segala kesalahan dan kekhilafan, wassalam.

Bukittinggi, 17 Februari 2010

Prof. Dr. Ir. H. Isril Berd, SU
Dekan Fakultas Teknologi Pertanian
Universitas Andalas

Kata-kata Aluan Pengerusi Pusat Pengajian Sains Kimia & Teknologi Makanan, Fakulti Sains Teknologi-UKM



Dengan nama Allah yang Maha Pengasih & Penyayang
Selawat dan salam ke atas junjungan Rasulullah saw

Assalamualaikum & selamat sejahtera

Saya ingin mengucapkan terima kasih kepada JK Penganjur kerana memberi kesempatan kepada saya untuk menyampikan sepatah dua kata di dalam Buku Program dan Abstrak ISFAS 2010. Tahniah diucapkan kepada Jawatankuasa Penganjur antara UKM dengan UNAND di atas kejayaan menganjurkan International Seminar on Food and Agricultural Sciences (ISFAS 2010) di Bukittinggi, Indonesia.

Penganjuran ISFAS 2010 bertujuan untuk menyediakan satu platform untuk memperkenalkan PPSKTM di peringkat antarabangsa. Melalui ISFAS ini, jaringan penyelidikan dan pertukaran idea dalam ilmu-ilmu terkini dalam bidang makanan dan teknologi pertanian dapat dilakukan dengan jayanya melalui pembentangan hasil penyelidikan yang telah dilakukan. Negara Malaysia dan Indonesia merupakan Negara yang kaya dengan hasil semulajadi dan pertanian. Oleh itu, amatlah wajar kedua-dua institusi UKM dan UNAND mengambil peluang ini untuk memperkembangkan aktiviti penyelidikan supaya jaringan dan kerjasama yang dibina.

Saya yakin ISFAS 2010 akan menjadi suatu medan pertukaran ilmu, kemahiran dan kepakaran yang boleh dogunakan untuk mempertingkatkan lagi kualiti penyelidikan para peserta khususnya dalam bidangn yang berasaskan makanan dan pertanian.

Akhir kata, saya ingin merakamkan setinggi-tinggi penghargaan kepada Jawatankuasa Penganjur ISFAS 2010 yang telah berkerja keras dan berdedikasi di dalam menjalankan tanggungjawab untuk menganjurkan seminar kali pertama ini. TAHNIAH.

Sekian, terima kasih.

Prof. Dr Jumat Salimon

Pengerusi, Pusat Pengajian Sains Kimia Dan Teknologi Makanan

Kata-kata aluan Dekan FST-Universiti Kebangsaan Malaysia



Dengan nama Allah yang Maha Pengasih & Penyayang
Selawat dan salam ke atas junjungan Rasulullah saw

Assalamualaikum & selamat sejahtera

Saya ingin mengambil kesempatan ini untuk mengucapkan tahniah kepada Pusat Pengajian Sains Kimia dan Teknologi Makanan (PPSKTM), Fakulti Sains & Teknologi bersama Fakulti Teknologi Pertanian, Universitas Andalas yang telah mengambil inisiatif untuk mengadakan International Seminar on Food and Agricultural Sciences 2010 buat kali pertamanya ini. Seminar seperti ini sangat penting untuk memfokuskan penyelidikan yang dilakukan dalam bidang Sains Makanan, Pertanian dan yang berkaitan dengannya di samping dapat mengoptimumkan pengemblingan tenaga penyelidik agar penyelidikan dapat dilakukan secara terstruktur dan tidak berlaku pertindihan. Saya yakin dengan kepakaran yang ada di PPSKTM dan FST amnya, penyelidikan dalam disiplin ini dapat dilakukan dengan lebih agresif dan terfokus serta mampu menghasilkan banyak KPI yang berkualiti, yang berupaya memberikan impak yang tinggi kepada perkembangan ilmu dalam bidang ini, bukan sahaja dalam negara tetapi juga di luar negara. Ini adalah sejajar dengan aspirasi Universiti Kebangsaan Malaysia (UKM) sebagai Universiti Penyelidikan yang menyimpan hasrat untuk menjadi universiti terbilang di dunia menjelang tahun 2018. Dengan semangat kerja berpasukan yang tinggi, saya yakin penyelidikan yang dilakukan dalam disiplin Sains Makanan ini mampu melonjakkan bukan sahaja nama Fakulti tetapi juga nama UKM di persada antarabangsa. Saya juga mengharapkan agar Seminar Bersama yang dijalankan akan mengeratkan hubungan silaturrahim antara kakitangan akademik FST dan FTP melalui kerjasama penyelidikan yang telah dirancang. Saya juga berharap pemetraian Surat Hasrat (LoI) antara FST, UKM dan FTP, Unand sempena seminar ini akan membuka lembaran baru untuk pelbagai aktiviti kerjasama di antara kedua-dua institusi.

Saya turut ingin mengucapkan tahniah kepada JK Penganjur yang telah bekerja keras di belakang tabir sehingga penganjuran seminar ini dapat direalisasikan. Harapan saya, semoga seminar seumpama ini akan terus dianjurkan secara berkala selepas ini, untuk mengekalkan sinergi dalam penyelidikan berkaitan Sains Makanan dan yang berkaitan, bukan setakat antara UKM dan Unand tetapi juga universiti lain.

Selamat berseminar !

Sekian terima kasih.

Prof. Dr. Musa Ahmad
Dekan Fakulti Sains & Teknologi

Kata-kata Aluan NAIB CANSELOR Universiti Kebangsaan Malaysia

Dengan nama Allah yang Maha Pengasih & Penyayang
Selawat dan salam ke atas junjungan Rasulullah saw

Assalamualaikum & selamat sejahtera

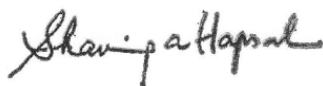
Tahniah diucapkan kepada Jawatankuasa Penganjur antara UKM dengan UNAND di atas kejayaan menganjurkan International Seminar on Food and Agricultural Sciences (ISFAS 2010) di Bukittinggi, Indonesia. Saya juga ingin mengucapkan terima kasih kepada JK Penganjur kerana memberi kesempatan kepada saya untuk menyampikan sepatah dua kata di dalam Buku Program dan Abstrak ISFAS 2010.

Seminar ini bertujuan untuk mengukuhkan karyawan-karyawan ilmu antara UKM dan UNAND melalui pembentangan dan pertukaran idea semasa seminar ini berlangsung. Kerjasama penyelidikan (LOI) yang di meterai melalui seminar ini akan mengeratkan serta mengukuhkan jaringan penyeliidkan antara kedua-dua pihak. Kesenambungan kerja-kerja penyelidikan harus dikekalkan serta di utuhkan lagi melalui seminar yang dirancang ini khususnya dalam ilmu makanan, kimia, pertanian dan bahan semulajadi. Selaras dengan pengumuman UKM sebagai Universiti Penyelidikan, maka sewajarnya kepakaran yang sedia ada di UKM patut dikembangkan serta di perluaskan hingga keperingkat antarabangsa.

Saya merasa gembira dengan sambutan yang menggalakkan daripada para penyelidik dan pelajar siswazah daripada pelbagai institusi pengajian tinggi khususnya UKM dan UNAND. Adalah diharapkan dengan aktiviti seperti ini akan meningkatkan mutu serta mengembangkan skop penyelidikan di mana segala maklumat dan ilmu pengetahuan yang diperolehi boleh dikongsi bersama demi kelestarian industri berasaskan makanan dan teknologi pertanian.

Akhir kata, saya ingin merakamkan setinggi-tinggi penghargaan kepada Jawatankuasa Penganjur ISFAS 2010 kerana telah Berjaya menganjurkan seminar kali pertama ini. Penganjuran ini tidak akan Berjaya tanpa kerja keras dan dedikasi daripada setiap ahli dalam jawatankuasa ini. Saya berdoa agar ISFAS 2010 akan mencapai matlamat penganjurannya.

Sekian.



Prof. Tan Sri Dato' Dr. Sharifah Hapsah Syed Hasan Shahabudin
Naib Canselor
Universiti Kebangsaan Malaysia

Opening Remarks by the Rector of the Universitas of Andalas



Bismillahirrahmanirrahim,
Assalamualaikum dan selamat sejahtera

First of all, thank to Allah, the Almighty, for blessing us good health that we all could come to this seminar. I would like to congratulate the Faculty of Agricultural Technology, Andalas University, which has taken the initiative to organize a joint seminar with Faculty of Science and Technology, Universiti Kebangsaan Malaysia. This International Seminar on Food and Agricultural Sciences (ISFAS2010) is part of collaborative activities between the two universities as the following up of the Memorandum of Understanding (MOU) signed on the 7th of March 2008.

As the oldest university outside Java, Universitas Andalas is committed to be excellent in research and teaching. Recently, we are preparing Universitas Andalas as one of the world class university.

The theme of the seminar, which is “improving the quality of life through food and agricultural sciences”, is a challenge for us, where the quality of life is closely linked with the quality of food which is produced from sustainable agriculture. It is expected that this seminar, would strengthen networking and cooperation among researchers at the two universities.

Last but not least, I would like to thank the organizing committee for the hard work and full commitment. I also would like to express my deep gratitude to the Director General of Higher Education of Republik Indonesia, the Vice Chancellor of Universiti of Kebangsaan Malaysia, The Dean of FST, UKM, Walikota Bukittinggi who welcomed us, key note speaker and participants for their valuable contributions on this seminar. I wish you all the best and hope Allah, the Almighty, supports all good efforts that we have been doing.

Thank you very much,

Prof. Dr. Musliar Kasim
Rector, Universitas Andalas

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DETERMINATION EQUILIBRIUM MOISTURE CONTENT OF FRAGRANT TEA IN PAPER PACKAGING USING GAB (GUGGENHEIM ANDERSON DE BOER) METHOD

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ABSTRACT

From the experiment, the critical water content by the GAB method for fragrant tea is 3.8680% (db). The result then had been generalized and obtained the critical moisture content is 4.71%. The moisture content of fragrant tea in paper packaging is exceed compared to the equilibrium moisture content, however the tea was still in a good quality.

Keywords

GAB equation, black tea, fragrant, expired date, storage period, shelflife

INTRODUCTION

Tea is a very popular beverage for people in Indonesia and all over the world. Many types of tea have been planted. Different products are manufactured by various techniques and various places. There are two type of tea in the Indonesian market that commonly consumed. The one is black tea and the other one is fragrant tea (jasmine tea). Green tea are usually consumed for special purposes i.e. diet and disease prevention. Tea is available in the form of leaf tea, instant, and the tea bag.

The sorption isotherm of a tea particle indicates the water activity, at which tea particle is stable and allows predictions of the effect of change in moisture content on water activity and hence on storage stability. It can help to define the rate and the extent of drying, the optimum storage temperature, and the moisture barrier properties required in packaging materials.

Numerous models for predicting the relationship between equilibrium moisture, water activity and temperature have been developed (Van den Berg and Bruin, 1981). Some of them take into account the effect of temperature. The modified Chung–Pfof (Chung and Pfof, 1967), modified Henderson (1952), modified Halsey (1948), modified Oswin (1946) and Guggenheim–Anderson–de Bour (GAB) (Van den Berg, 1984) equations have been adopted as standard equations by the American Society of Agricultural Engineers for describing sorption isotherms (ASAE, 1995). The equations of Brunauer–Emmett–Teller (BET) (Brunauer et al., 1938) and GAB provide the monolayer moisture content; both can be considered to be the most useful ones for determining the optimum

moisture conditions for good storage stability, especially for dehydrated foods.

Only a few sorption isotherms of tea have been reported. Wolf et al. (1973) had listed some sorption data of tea at 20 °C. Jayaratham and Kirtisinghe (1974) used saturated salt solutions to determine the equilibrium moisture content values for a stored black tea at 20°C. Studies on black teas from Kenya using the saturated salt method were carried out by Doughan et al. (1979). Temple and van Boxtel (1999) measured the sorption data of Central African tea at 40, 60, and 80 °C and produced data on equilibrium moisture of tea in a form that can be used in modeling the drying process. Panchariya et al. (2001) determined the EMC of black Darjeeling tea at several temperatures ranging from 25 to 80 °C. Arslan and To-grul (2006) measured Turkish black tea at three temperatures. Ghodake et al. (2007) reported the sorption isotherm of withered leaves, black, and green tea. Chen and Wang (2008) reported moisture sorption isotherm of oolong tea. However, there is no report about the sorption properties of the fragrant tea.

Lomauro et al. (1985) attempted to fit data from tea to various equations, concluding that the GAB model showed the best fit, followed by the Oswin model. The GAB equation is usually presented in the form:

$$W = \frac{W_m C K a_w}{(1 - K a_w)(1 - K a_w + C K a_w)} \quad (1)$$

where W is the moisture content (d.b.), a_w is the water activity, and W_m , K , and C are the three free sorption parameters characterizing sorption properties of the material. The W_m denotes moisture content corresponding to the ‘monomolecular layer’ on the whole free surface of the material; the parameters K and C depend on temperature by Arrhenius-type equations (van den Berg 1984) with corresponding molar sorption enthalpies. In a previous paper (Blahovec 2004), it was shown that parameters K and C should fulfill the following relations: $0 < K \leq 1$, whereas C should be higher than 0. For $C \geq 2$, the GAB equation gives a sigmoidal shape curve with point of inflection (type II of Brunauer’s (1943) classification); however, for $0 < C < 2$, the isotherm is of the type III only (isotherms without point of inflexion).

The GAB model is the most widely used equation to describe water sorption of food products. A generalization of the standard Guggenheim, Anderson, de Boer (GAB) equation is presented by Blahovec and Yanniotis (2008), which is based on the assumption that the parameter C of the GAB equation is not constant but rather some polynomial function of the water activity a_w . It is shown that the standard GAB equation is adequate to describe experimental data for water activity values up to 0.90 but fails to adequately describe the experimental data when data in the range of a_w 0.9–1.0 are included in the calculations. The generalized GAB form leads to successful description of the sorption data for water activity values from 0 to 1.

The monolayer moisture content M_o is recognized as the optimum moisture content for good storage stability (Labuza et al. 1970). This M_o value is the critical moisture content for tea to keep flavor and quality. The Brunauer–Emmett–Teller (BET) and GAB equations were usually applied to calculate this specific value (Quirijns et al. 2005; Timmermann et al. 2001). If the moisture content of the products is exceeded the EMC or M_o , we could assume that the products have reached their expiry period.

The objectives of this study are (1) to determine the EMC for fragrant tea in a paper packaging stored at ambient temperatures for relative humidity in the range of 10–90%; (2) to evaluate the quality of fragrant tea in a paper packaging from market places,

MATERIALS & METHODS

Materials

The fragrant tea used in the sorption isotherms experiments were collected from the supermarket at Surabaya Indonesia. Total samples 45 from 5 brands, 9 samples of each brand were collected from the supermarket. The expired date stated on the packaging by producers.

Methods

The sorption method used was the static gravimetric technique, which is based on the use of saturated salt solutions to maintain a fixed relative humidity when the equilibrium is reached. The water activity of the food is identical to the relative humidity of the atmosphere at equilibrium conditions and the mass transfer between the product and the ambient atmosphere is assured by natural diffusion of the water vapor. Seven saturated salt solutions (CaCO_3 , LiCl , CH_3COOK , MgCl_2 , $\text{Mg}(\text{NO}_3)_2$, NaCl , dan KCl .) were prepared corresponding to a wide range of water activities ranging from 0.1 to 0.9 (Hall, 1957). Seven glass desiccators were used for this study. Each desiccator was provided with a perforated and raised platform and the level of saturated salt solutions in it was kept below the perforated platform in order to avoid contact of the salt solution with the sample holder. For each of these experiments about 2 ± 0.1 g fragrant tea was taken separately into the respective weighing bottles.

All these seven desiccators were put in ambient temperature room and the gain or loss in weights of all these samples in each desiccator was monitored for every two days. The EMC was acknowledged when three consecutive weight measurements showed a difference of less than 0.001 g. This took about 20–30 days, depending on the nature of the samples and the temperature inside the room. Three replications were kept for each sample and the average values of EMC have been reported. The EMC of each sample was determined with the help of a drying oven whose temperature was fixed at 105°C.

Data Analysis

The software, “GAB,” which was written by Labuza and Sapru (1991), was used to execute the GAB model and to calculate M_o . In this study, the researchers used EXCEL 2003 to generalize the GAB formula by changing the rigid value of C to a polynomial function of a_w so that the obtained model will fit the experimental data in the whole range of a_w especially in the range of water activity values of 0.9–1.0, which is very important for the stability of foodstuffs.

RESULTS & DISCUSSION

GAB curve

The a_w and moisture content measurement of the black tea and fragrant tea is presented in Table 1.

Table 1. The a_w and moisture content (mc) measurement of fragrant tea

Solution	Fragrant tea	
	a_w	mc (% db)
CaCO_3	0.03	0.73
LiCl	0.19	3.44
CH_3COOK	0.30	5.17
MgCl_2	0.53	5.95
$\text{Mg}(\text{NO}_3)_2$	0.62	7.38
NaCl	0.76	12.01
KCl	0.79	15.11

Moisture sorption isotherm

From the moisture sorption isotherm curve obtained from GAB program using input data from Table 1, the M_o value, k value, C value of fragrant tea are 3.87% db, 0.91, and 10.08 respectively (Figure 1). The k is a correction factor of the secondary and tertiary water layers, therefore the GAB equation are not only appropriate to describe the primary water areas but also can be applied to the tertiary water area.

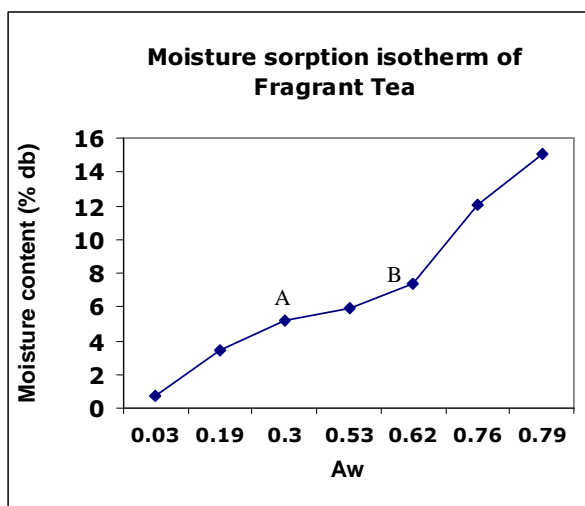


Figure 1. Moisture sorption isotherm of Fragrant Tea

C is a constant value that can indicate GAB isotherm type material. In this study, $C \geq 2$ then the material are included in the type II isotherm. The type II isotherm will form the sigmoid curve with two point of inflection between 0.2-0.4 and a_w 0.6-0.7. Most of food products, especially dry food are included in the type II isotherm. The critical point is indicated by the value of M_0 , 3.87%. The K and C are produced, respectively 0.91 and 10.08. This is in accordance with Blahovec (2004) that the value of K which is a water correction factor of secondary and tertiary layers must satisfy $0 < K \leq 1$ and the value of C which is an important determinant of the curve must be ≥ 2 . Value of $C \geq 2$ will produce sigmoid-shaped curve.

The primary water layer (I) are shown (Figure 1.) in the area before the first point of inflection (point A) on the curve, water is strongly bond to other molecules such as carbohydrates, proteins, or salt through a hydrogen bond. The secondary water layer (II) are water molecules that form hydrogen bonds with other water molecules and the nature of the bonds is not as strong as the primary water layer. The secondary water layer is shown in the area between point A and point B on the moisture isotherm curve. The tertiary water layer (III) so-called free water is shown in area after point B., the water physically bond within the network such as the matrix membrane material, capillary, and fiber.

Generalization GAB equation

The GAB equation, a three-parameter model, has been used in recent years for the approximation of experimental data. The GAB equation is successful in many cases, but there are also cases where the GAB equation fails to describe some sorption isotherms, especially at higher water activities. By generalizing GAB equation Blahovec and Yanniotis (2008) conducted research with the aim of GAB equation can be applied to products with a_w between 0 - 1.0. In the study stated that the GAB equation can not be applied to several isotherm sorption especially

at high a_w . The generalization of the GAB isotherm is based on the assumption that the parameter C is not constant but rather some function of the water activity a_w that can be expressed in the following special polynomial form:

Orde 3:

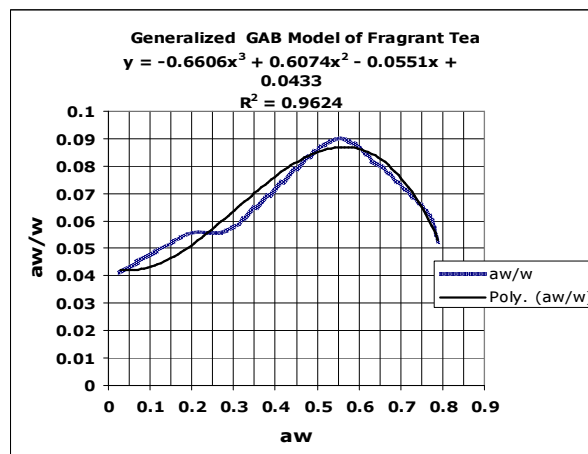
$$a_w/w = a' + b' a_w + c' a_w^2 + d' a_w^3 \quad (2)$$

Orde 4:

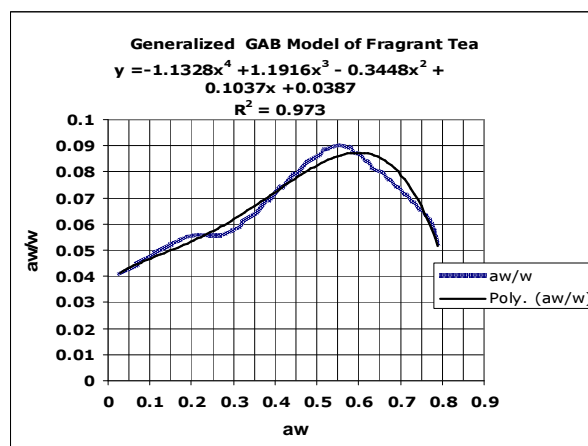
$$a_w/w = a'' + b'' a_w + c'' a_w^2 + d'' a_w^3 + e'' a_w^4 \quad (3)$$

$$w = \text{equilibrium moisture content}$$

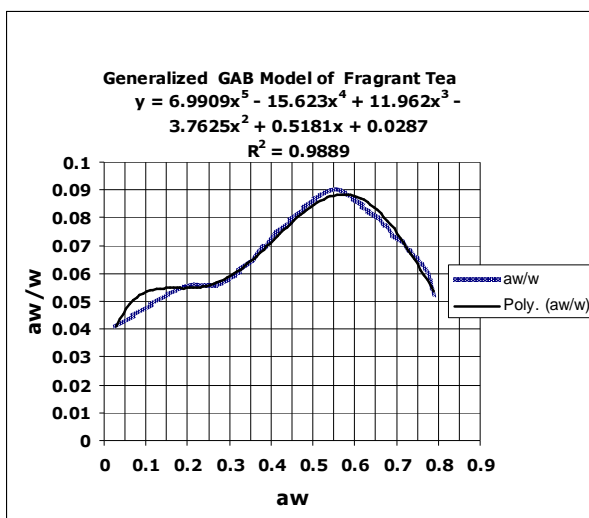
Stage that needs to be done is making a graph with the X-axis is a_w and a_w/w as the Y-axis. Graphic generalized GAB model using EXCEL 2003 is presented in Figure 2. (a) (b) (c).



(a) Order 3



(b) Order 4



(c) Order 5

Figure 3. Graphic GAB Order 5 Generalization for Fragrant Tea

The standard GAB equation was fitted to the experimental data of fragrant tea initially to the polynomial order 3 (Figure 3. (a)), the coefficient of determination for this fit is about 0.962. However, when higher order polynomials on the right side of each equation are used, a higher coefficient of determination is obtained. For example, for polynomial of the fourth order (Fig. 3 (b)), the coefficient of determination is 0.973; whereas for the polynomial of the fifth order, the coefficient of determination is 0.989.

Based on the generalized GAB equation, the equilibrium water content can be obtained by insert a_w value into the fifth-order equation. a_w replace the variables as follows:

$$a_w/w = 6,898 a_w^5 - 15,41 a_w^4 + 11,78 a_w^3 - 3,698 a_w^2 + 0,509 a_w + 0,028$$

$$0.26/w = 6,898 \cdot 0.26^5 - 15,41 \cdot 0.26^4 + 11,78 \cdot 0.26^3 - 3,698 \cdot 0.26^2 + 0,509 \cdot 0.26 + 0,028$$

$$w = 4.71\%$$

Based on the above calculations, it is known that the equilibrium water content of fragrant tea is 4.71% .

The fragrant tea in paper packaging from the supermarket have moisture content $9.11 \pm 0.51\%$. This is indicate that fragrant tea product is expired. But in fact the tea is still good, and no tainted flavor and tea aroma is still retained, this shows that tea has a component can maintain its own quality. The expired date that stated by producer at packaging material indicate that the fragrant tea in that packaging is still available.

CONCLUSION

From the experiment is known that the GAB program obtained results for the critical water content of the fragrant tea is 3.87% (db), and after generalized is 4.71%.

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