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by Tarsisius Dwi Wibawa Budianta .

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, shelf-life

INTRODUCTION

People all across the world, including in Indonesia, like drinking tea. There are numerous varieties of tea plants. Different items are produced using different methods in different locations. There are two types 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 tea particle's sorption isotherm reveals the water activity at which the tea particle is stable and enables predictions of the impact of changes in moisture content on water activity and, consequently, storage stability. Determining the rate and extent of drying, the best storage temperature, and the moisture barrier qualities necessary in packaging materials can all be aided by this information.

There are many models that have been created to anticipate the link between equilibrium moisture, water activity, and temperature (Van den Berg and Bruin, 1981). Some of them consider the impact of temperature. The American Society of Agricultural Engineers has adopted the modified Chung-Pfost (Chung and Pfost, 1967), modified Henderson (1952), modified Halsey (1948), modified Oswin (1946), and Guggenheim-Anderson-de Bour (GAB) (Van den Berg, 1984) equations as the standard equations for describing sorption isotherms (ASAE, 1995). The monolayer moisture content is calculated using the Brunauer-Emmett-Teller (BET) and GAB equations (Brunauer et al., 1938), which are both thought to be the most helpful for identifying the ideal conditions.

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 sat urated 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 T ogrul (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:

$$W = \frac{W_m\,CKa_w}{(1-Ka_w)\,(1-Ka_w\;+CKa_w} \,. \qquad (1)$$

When Wm, K, and C are the three free sorption parameters describing the sorption properties of the material, and W is the moisture content (dry base/ db), a_w is the water activity. The parameters K and C depend on temperature via Arrhenius-type equations with corresponding molar sorption enthalpies (van den Berg, 1984); the Wm signifies moisture content equivalent to the "monomolecular layer" on the entire free surface of the material. It was demonstrated in a previous study (Blahovec 2004) that parameters K and C should satisfy the following relations: (isotherms without point of inflexion).

The GAB model is the equation that is most frequently used to describe how water sorption occurs in food products. Blahovec and Yanniotis (2008) provide a generalization of the conventional Guggenheim, Anderson, de Boer (GAB) equation based on the presumption that the parameter C in the GAB equation is not a constant but rather a polynomial function of the water activity aw. It is demonstrated that the traditional GAB equation can effectively describe experimental data for water activity values up to 0.90, but when data in the range of aw 0.9-1.0 are included in the calculations, the equation falls short. The sorption data are successfully described using the generalized GAB form for water activity values ranging from 0 to 1.

The ideal moisture content for stable storage is known as the monolayer moisture content Mo (Labuza et al. 1970). The essential moisture level for tea to maintain flavor and quality is indicated by the Mo value. To determine this particular value, the Brunauer-Emmett-Teller (BET) and GAB equations were typically used (Quirijns et al. 2005; Timmermann et al. 2001). If the moisture content of the products is exceed the EMC or Mo, we could assumed that the products has reach 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 this study 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 static gravimetric technique, which is based on the use of saturated salt solutions to maintain a stable relative humidity until the equilibrium is attained, was the sorption method that was employed. The mass transfer between the product and the ambient atmosphere is ensured by natural diffusion of the water vapor since the water activity of the food is similar to the relative humidity of the atmosphere at equilibrium conditions. Seven saturated salt solutions ($CaCO_3$, LiCl, CH_3COOK, $MgCl_2$, $Mg(NO_3)_2$, NaCl, and KCl) that correspond to a wide range of water activity between 0.1 and 0.9 were made (Hall, 1957). For this study, seven glass desiccators were used. The level of saturated salt solutions in each desiccator's perforated and elevated platform was measured. For each of these experiments about 2±0.1 g fragrant tea was taken separately into the respective weighing bottles. All seven desiccators were placed in ambient temperature rooms, and every two days, the weight gain or loss of each sample in each desiccator was tracked. When the difference between three consecutive weight readings was smaller than 0.001 g, the EMC was recognized. Depending on the type of samples and the temperature in the room, this process required 20 to 30 days. Each sample had three replications, and the average EMC values have been published. A drying oven with a predetermined temperature of 105°C was used to calculate the EMC of each sample.

Data Analysis

The GAB model was run, and Mo was calculated, using the "GAB" program that Labuza and Sapru (1991) created. In this study, the researchers generalized the GAB formula using Excel 2003 by changing the rigid value of C to a polynomial function of aw so that the obtained model would fit the experimental data in the entire range of aw, especially in the range of water activity values of 0.9-1.0, which is crucial for the stability of foods.

RESULTS & DISCUSSION

GAB curve

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

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

	Fragrant tea	
Solution	aw	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
$Mg(NO_3)_2$	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 Mo 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 is not only appropriate to describe the primary water areas but also can be applied to the tertiary water area.

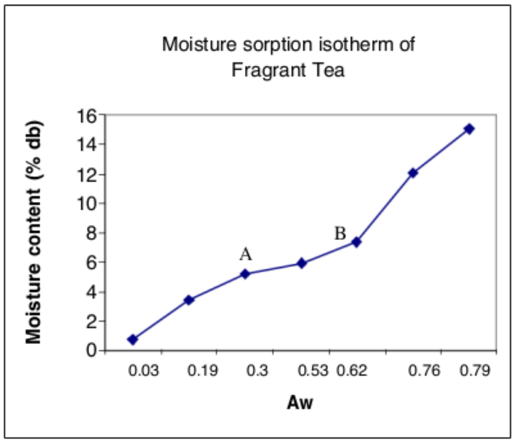


Figure 1. Moisture sorption isotherm of Fragrant Tea

C is a constant value that can indicate GAB isotherm type material. In this study, C ≥ 2 then the material are included in the type II isotherm. The type II isotherm will form the sigmoid curve with two points of inflection between 0.2-0.4 and aw 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 Mo, 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 ter-tiary layers must satisfy 0 <K ≤ 1 and the value of C which is an important determinant of the curve must be ≥ 2. Value of C ≥ 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 be-tween 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

In recent years, the three-parameter GAB equation has been utilized to approximate experimental data. Although the GAB equation frequently succeeds, there are some instances, particularly at higher water activity, where it fails to capture some sorption isotherms. By generalizing GAB equation Blahovec and Yanniotis (2008) conducted research with the aim of GAB equation can be applied to products with aw be-tween 0 - 1.0. In the study stated that the GAB equation cannot be applied to several isotherm sorption especially at high a_w. The assumption behind the generalization of the GAB isotherm is that the parameter C is not a constant but rather some function of the water activity aw that can be written in the particular polynomial form shown below:

Orde 3:

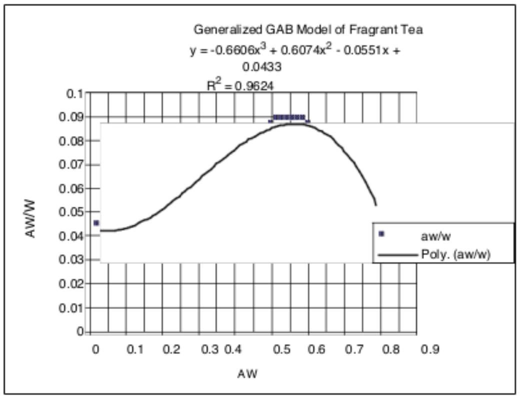
$$a_w/w = a' + b'\,a_w + c'\,a_w^2 + d'\,a_w^3 \qquad (2)$$

Orde 4:

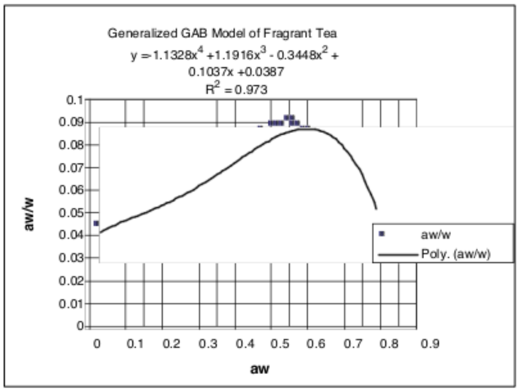
$$a_w/w = a'' + b''\,{}_{w}a + c''\,a_w^2 + d''\,a_w^3 + e''\,a_w^4 \qquad (3)$$

w = *equilibrium moisture content*

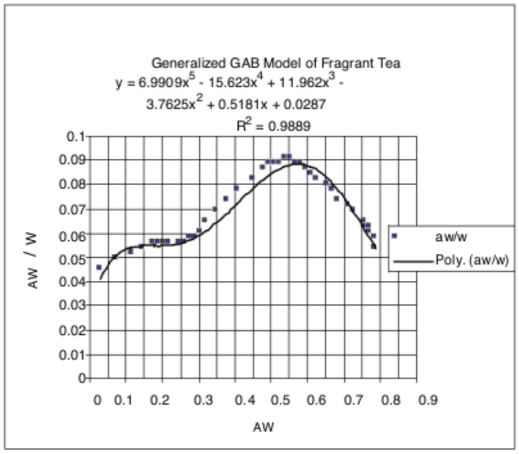
Stage that needs to be done is making a graph with the X-axis is aw and aw /w as the Y-axis. Graphic generalized GAB model using EXCEL 2003 is presented in Figure 2. (a) (b) (c).



(a) Order 3



(b) Order 4



(c) Order 5

Figure 3. Graphic GAB Order 5 Generalization for Fragrant Tea

The experimental data on fragrant tea were originally fitted with the conventional GAB equation to a polynomial order of 3 (Figure 3. (a)); the coefficient of determination for this fit is approximately 0.962. However, a larger coefficient of determination is obtained when higher order polynomials are utilized on the right side of each equation. For instance, the coefficient of determination for the polynomial of the fourth order (Fig. 3(b)) is 0.973, but the coefficient of determination for the polynomial of the fifth order 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:

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

$$0.26/w = 6,898 . 0,26^5 - 15,41 . 0,26^4 + 11,78\ . 0,26^3\ -$$

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 ± 0.51%. This is indicate that fragrant tea product is expired. But in facts 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 pack-aging 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%.

ACKNOWLEDGMENTS

This research was conducted at the Department of Food Technology, Faculty of Agricultural Technology, Widya Mandala Surabaya Catholic University. The authors acknowledge the financial support from Rector and Ketua LPPM Widya Mandala Surabaya and special tank for the technical assistant from Yuyun Oktavia and Hanny Ariesta.

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