hasil penelitian

A STUDY ON THE SORPTION ISOTHERM AND SHELF LIFE OF INTERMEDIATE-MOISTURE BANANA (IMB)

Oleh :

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Summary

Water vapour sorption isotherm of intermediate moisture banana (IMB) was studied by means of saturated salt solution technique at 22.2°C. The desoprtion and adsorption isotherms of IMB were sigmoid shape and indicate a hysteresis loop.

The shelf life of IMB based on the hardening phenomena in polyethylene pouch stored at 22.2°C and RH 50% and 73% ferpouch was investigated. In a 73% RH chamber, IMB in the package theoretically would never harden to a critical point. The shelf life of IBM with a critical a_w 0.5 (equivalent to about 11.0% moisture content) in the 50% RH chamber was 74 — 79 days.

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I. Introduction

In general, intermediate food are expected to be reasonably stable under storage and marketing conditions (Gal, 1983; Gilbert, 1986). The stability is due to their lower water activity (a_w) compared to that of the fresh material, but this is not as low as that of the fully dehydrated product.

The crispness of dry, cereal-based foods is a strong function of a_w as found by Katz and Labuza (1981). At a_w value of 0.4 — 0.5, the cracker loses its, desirable crispness. In fact, for most cereal and cereal based producst, significant loss of crispness occurs in this a_w range. Thus, the moisture sorption can be used to predict the critical moisture content or a_w above which the product should go during distribution.

Hardening, on the other hand, is a problem relating to intermediate foods such as semimoist foods, intermediate moisture fruits, and pet foods. Not enough data exist to predict a lower critical a_w for hardness because this critical a_w depends on product composition. Fat and glycols, for example, can lower the critical a_w for the product they are in. For most of intermediate foods, the critical a_w will be around 0.5 — 0.6 (Labuza, 1984).

The above information presented some typical critical a_w s that can be used to determine a maximum allowable moisture gain or loss from the initial state. The moisture sorption isotherm can be used to determine the critical moisture content. Some e quations have been derived to estimate the gain or loss of moisture for a food held in a semipermeable package (Labuza, 1984).

An equition for predicting the shelf life of food held in a semipermeable package has been derived by Downes and Giacin (1989) as follows :

$$t = \frac{-2.3\ W}{P\ Ps\ b} \times \log\left(\frac{(RHext - RHint)}{(RHext - RHint)}\right) \quad (1)$$

where,

t = shelf life, in days

W = weight of product in a package as dry material in grams

P = permeability constant of the package, in g H_2O per day-package-mmHg.

Ps = saturation vapor pressure, in mmHg.

b = inverse of isotherm slope in g dry matter/g H_2O per a_w unit.

RHext = RH outside the package, %

RHint = RH inside the package, % at time i, RH int is the average value of corresponding RH at the initial and critical points.

Several intermediate tropical fruits have been studied by many researchers. Levi *et al.* (1983) reported some technological data on intermediate moisture papaya; meanwhile some aspects on preserving quality of intermediate moisture banana was studied by Levi (1980) and Martinez (1977.

Intermediate moisture bananas (IMB) are widely produced in Indonesia for the intention of both post harvest product saving and retaining the quality characteristics, such as flavour, colour, appearance and texture, yet limited resport appears on the literature.

The objective of this research was to determine the sorption isotherm shape and the shelf life of IMB based on hardeing phenomena.

II. Materials and Methods

Intermediate moisture banana (IMB)

Fresh ripe bananas (Gros Michel) were purchased from local supplier at Michigan, USA. The IMB was prepared by peeling the ripe bananas and then dried in a forced air dryer at 75°C. for 20 hr (Proctor & Schwartz; Inc).

Package

Low density polyethylene ziploc pouches (6.5" × 5.875" × 1.15 mils; (The Dow Chemical Company) were used as the package model.

Water sorption determination

Following water content determination (AOAC, 1984) and complete drying of samples in a vacuum oven at 60°C during 8 hr, moisture adsorption isotherm was determined gravimetrically by placing the dried bone samples in vacuum chambers containing saturated salt solutions with relative humidities ranging from 22 — 73% (Labuza, 1984). For the study of desorption isotherm the IMB samples instead for dried bone samples were used.

The vacuum chambers were kept in a constant room temperature (22.2°C) for 15 days. All values of equilibrium moisture content (EMC) for the samples are expressed in the dry matter basis.

Water vapour permeability of the package and shelf life

The water permeability of the package was determined by monitoring the weight gain of desiccant-package system sealed with both ziplocing and heat sealing stored in a chamber (22.2°C temperature and 73% RH). Each package was filled with about 25 grams of Drierite desiccant.

For the study of shelf life, IMB were packed in the same manner as that for the water permeability study. Each package was filled with 19 — 20 grams IMB, and stored at 22.2°C chambers at 50% RH and 73% RH respectively.

The storage period for all of the study was 70 days, and the weight loss and weight gain of the samples were monitored periodicaly. All of the experiments were done in triplicate.

III. Results and Discuccion

IMB

The intermediate moisture bananas produced by the drying were yellowish in colour, containing 24.83% moisture (wet basis) or 33.03% on dry basis which in accordance with those reported by Levi (1980). The a_w of these IMB as determined by the sorption isotherm curve was 0.8 which was in the range of that ofsemimoist food (0.62 — 0.92) as stated by Labuza (1984).

Sorption Isotherm

The RH and EMC values of the IMB both for desorption and adsorption were given in Table 1.

Tabel 1. **EMC of IMB at Different RH at 22.2°C**

RH, %	**EMC, g/100g dry Wight**	
	Desorption	**Adsorption**
22.5	7.082	3.337
32	8.592	3.865
42	9.687	5.060
52 5	12.039	8.827
64	18.353	16.223
73	28.003	28.556

The EMC vs RH values were plotted to obtain a sorption isotherm curve by a 3 degree polynomial regression (variance = 0.09) as shown in Fig. 1.

The shape of sorption was agree with that of the Henderson's equation isotherm for dehydrated foods (Iglessias and Chirife, 1982). More water was held at the same a_w for the desorption curve than that for the adsorption curve below a clossure point (a_w 0.70).

The first reason for the differences in moisture content (hysteresis) was possibly because of the high sugar content of IMB Dur-

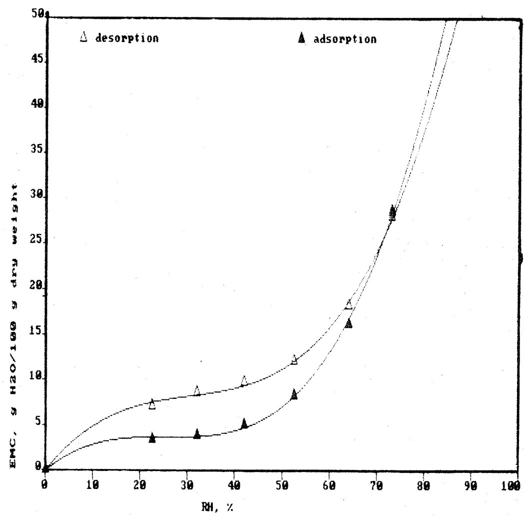

Fig 1. **Sorption Isotherm for IMB of 22.2°C**

The Regression Polynomial of line 1 : $(-7.210E-02) + (6.707E+01)x + (-1.964E+02)x^2 + 2.148E+02)x^3$, the variance — 9.128E—02; The Regression Polynomial of Line 2 : $(-6.482E-02) + (4.440E+01)x + (-1.749E+02)x^2 + (2,291E+02)x^2$ the variance — 9.361E—02;

ing desorption some solutes (e.g. sucrose) may supersaturate below their crystallization a_w and thus would hold more water. The second possible explanation was due to the narrow end of surface pores of IMB. In desorption the surface IMB's narrow ends will trap and hold water internally below the a_w where it should have been released; while in adsorption, the narrow end prevents the larger body from filling. The third reason was possibly caused by the difference in the surface tension for adsorption and desorption, resulting in a higher moisture content for desorption (Labuza, 1984).

Slope at The Desorption Curve for The Safe Storage Limits

The initial moisture content of IMB in the package was 33.03% dry basis, and the critical a_w value was assumed to be 0.5 (Labuza, 1984) which was equavalent to 10% moisture dry basis or 11.11% moisture wet basis. The moisture content was known as the possible safe storage limits and located in the linear regions of desorption curve (storage moisture isotherm).

The working (storage) moisture isotherm was superimposed on true desorption curve) (Fig.2)

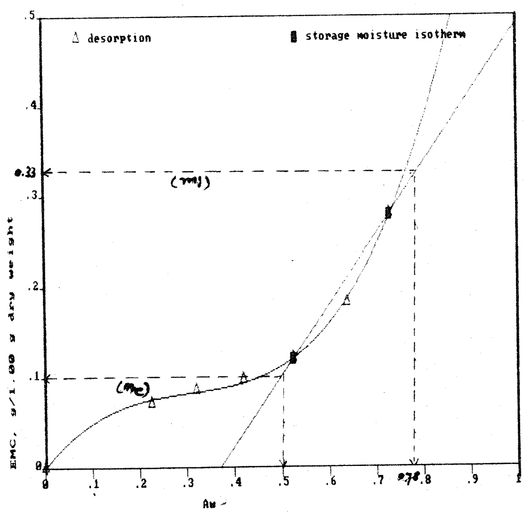

Fig 2. **Desorption Curve for IMB of 22,2°C**

The regression polynomial of line 1 : (—7.212E—04) + (6.707E—01)x + (—1.964E+00)x^2 + (2.148E+00)x^3 the variance — 9.128E—06; The Regression polynomial of line 2 : (—2.884E—01) + (7.787E—01)x; the variance — 4.441E—16

Dotted lines represent the initial (mi), and critical (mc) moisture limits, and the coresponding a_w as well. The slope of the desorption curve for the safe limits was found by linear regression at this region, i.e = 0.7787 g H_2O/g dry weight per unit a_w. This value represents the rate of moisture loss for IMB during storage in such conditions.

Water Vapor Permeability of The Package

The weight gain for the dessicant package systems during storage period were presened in Table 2.

Table 2. Weight gain of Desiccant-package at 22.2°C, 73% RH

Time, Days	Weight Gain, Grams	
	Ziploc	Heat-seal
0	0	0
4	0.309	0.311
9	0.489	0.528
14	0.528	0.613
17	0.558	0.677
24	0.583	0.705

These data were plotted as weight gain vs time as shown in Fig.3.

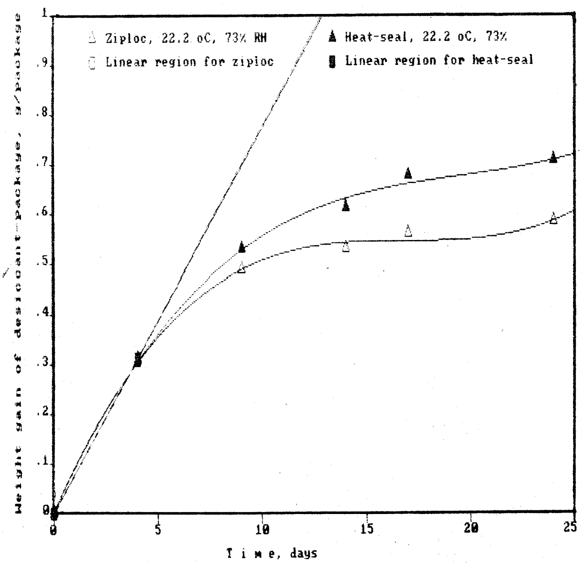

Fig 3. **Weight gain for desiccant**

The regression polynomial of line 1 : (2.637E—03) + (2.401E+00)x + (—3.543E+00)x^2 + (1.743E+00)x^3 the variance — 6.848E—05; The regression polynomial of line 2 : (3.140E—03) + (2.290E+00)x + (—2.734+00)x^2 + (1.159E+00)x^3 the variance — 1.134E—04; The regression polynomial of line 3 : (0.000E+00) + (7.725E-02)x the variance — 0.000E+00; The regression polynomial of line 4 : (0.000E+00) + (7.775E—02)X; the variance — 0.00E+00

At the first 4 days the weight gain was linear and leveled of because of saturation of the desiccant inside the package. The slope of the linear regions were determined by linear regressions. The slope for Ziploc package was 0.07725 , which was slightly less than that of heat-sealed (0.7775 g H_2O/day) indicating that the performance of Ziploc was not inferior to that of heat sealed package. The improper heat-sealing of the package might cause some deterioration on the sealing area that tended to slightly speed up the water vapour adsorption of the package.

The permeability constant for the package then was calculated by the following equation :

$$\bar{P} = \frac{\text{slope}}{\Delta P} \quad \ldots\ldots \quad (2)$$

where, P is permeability constant (g H_2O/day-package-mmHg) and Δ P is pressure difference given by saturated water pressure at temperature t $\times$ RH/100.

The permeability constant for Ziploc and heat-sealed package system were 0.00528 ans 0.00531 g H_2O/day-package-mmHg, respectively. Based on these data the permeability constant of the polyethylene materials for the package can be calculated as follows :

$$P = \frac{\text{slope} \times \text{thickness}}{\text{Area} \times \Delta P}$$

$$= \frac{0.07725 \text{ g } H_2O \times 1.15 \text{ mil}}{\text{day} \times 0.05 \text{ m2} \times 20.02\ (0.73) \text{ mmHg}}$$

$$= 0.12157 \text{ g } H_2O \text{ mil/m2 day mmHg.}$$

This experiment permeability constant for polyethylene was less than that of the literature's data, i.e. 0.21 (Labuza, 1984). The difference is probably because of the sealing conditions and type of desiccant used in the experiment, but the value was still in the tolerable range, because according to Labuza (1984) the data given by manufacturer are about three times higher than the actual values.

Shelf Life

The decreasing weight of the IMB-package during 70 days storage were given in Table 3.

The weight of IMB-package system stored in the 73% RH chamber did not change because the intial RH inside the package (76%) was almost the same as that of the storage chamber (73%). In this conditions the pressure gradient across the package is almost zero, so the water molecules could not pass throught the package wall. On the other hand, in the 50% RH storage chamber the IMB samples lost some amount of water as shown by the decreasing curves.

The maximum tolerable weight loss of the IMB can be calculated as 19.450 — (0.2483 — 0.1111) $\times$ 19.450 = 2.67 grams. The initial dry

Table 3. **IMB—Package Weight Loss During Storage**

Time, Days	Weight of IMB, Grams			
	RH 50%		RH 73%	
	Ziploc	Heat-seal	Ziploc	Heat-seal
0	19.453	19.405	19.405	19.213
7	18.551	18.514	19.434	19.215
14	18.302	18.297	19.435	19.218
28	17.473	17.346	19.438	19.232
42	17.224	17.210	19.442	19.234
56	16.923	16.907	19.445	19.234

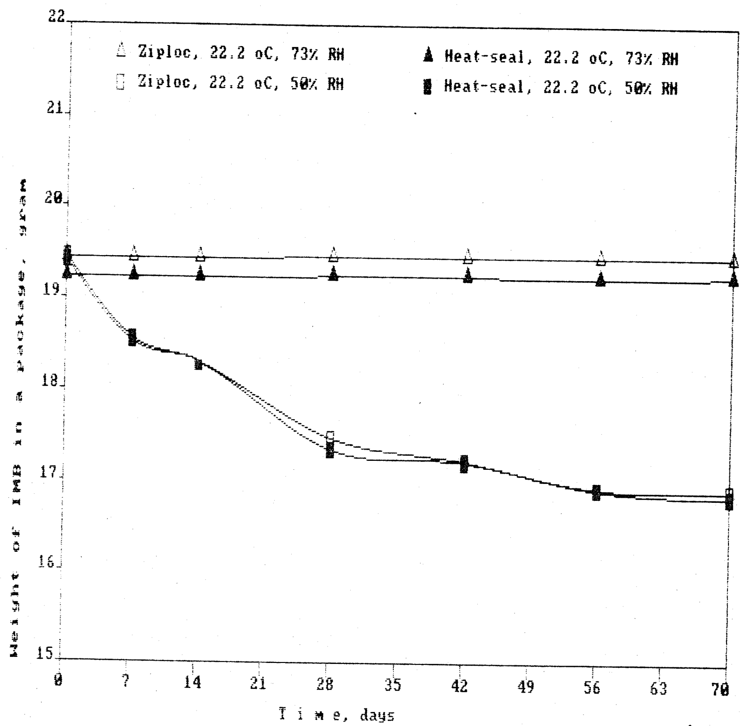

Fig 4. **Weight Loss of IMB in The Package**

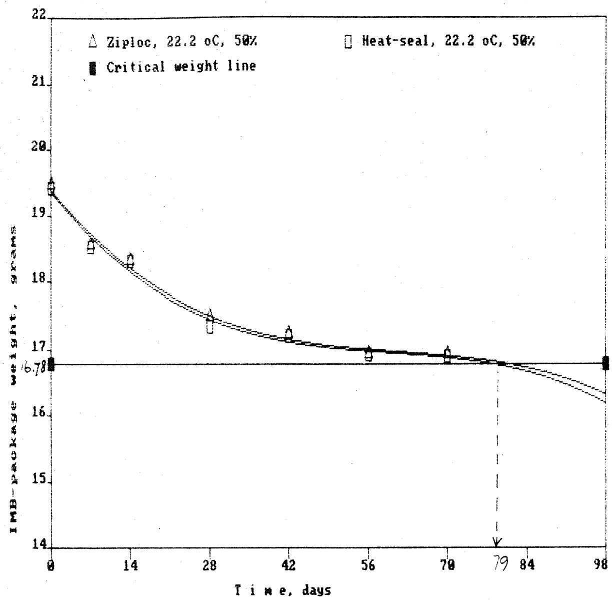

Fig 5. Graphical Prediction of shelf lifge for IMB

The regression polynomial of line 1 : (1.938E+01) + (—1,031E+01)x + $(1.541E+01)x^2$ + $(—8.168E+00)x^3$ the variance — 8.140E—03; The regression polynomial of line 2 : (1.935E+01) + (—1.065E+01)x + $(1.650E+01)x^2$ + $(—9.023E+00)x^3$ the variance — 1.098E—02

weight of IMB in the package = 19.450 (0.2483 × 19.450) = 14.6205 grams.

The shelf life of the IMB can be predicted by using equation (1).

$$t = \frac{-2.3 \times 14.6205}{0.00528 \times 20.07 \times 1/0.778} \times \log \left(\frac{(50 - (78 + 50)/2)}{(50 - 78)} \right)$$

t = 74 days

The existing data of weight loss during 70 days storage were generalized into three degree polynomial regression as shown in the Figure 5 (variance = 0.008 and 0.011).

The shelf life of IMB was predicted graphycally with the weight limit of 19.450 — 2.67 = 16,78 grams (Fig. 5). The predicted shelf life was 79 days (as shown by dotted line), and closed to 74 days which was calculated using equation (1).

IV. Conclusion

Some conclusion that can be derived from this study are as follows :

1. The sorption isotherm of IMB at 22.2.C was a sigmoidal shape with a certain value of hysteresis.
2. The slope of desorption line at the working moisture storage was 0.778 g H_2O/g dry weight per unit a_w.
3. The permeability constant of the package with Ziploc and heat-seal was 0.00528 and 0.00531 g H_2O/day-package-mmHg, respectively.
4. At a storage chamber of 73% RH, the IMB in the package theoretically would never harden because the intial RH inside the package was almost the same as RH of the storage chamber.
5. The shelf life of IMB stored at 22.2.C and 50% RH based on the hardening phenomena was 74 — 79 days.

Reference

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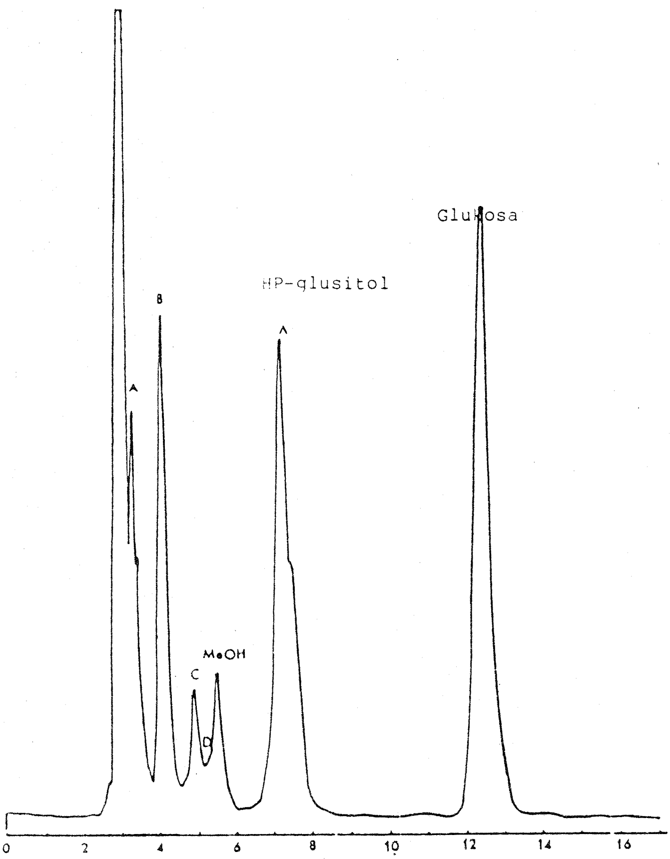
Tambahan Gambar 4.
Hasil Penelitian Dengan Penentuan Letak Hidrolisis Pati Hidroksipropil dengan Analisis HPLC
Agritech Vol. 9 No. 2 Mei 1989



Gambar 4. **Hasil Hidrolisis Asam Dari Pati Hidroksipropil Direduksi dan Dipisahkan Dengan Kolom** μ Poracil.