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Effect of temperature and water activity on quality deterioration and shelf life of dried mangoes

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ABSTRACT

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A study was conducted on the effect of storage temperature and sample water activity on ascorbic acid degradation, browning development and shelf life of dried mangoes. The moisture content of dried mangoes increased with water activity at all temperatures which is consistent with the theory of physical adsorption. However, at a water activity of about 0.65, the amount of sorbed water at a given water activity increased with increasing temperature. The ascorbic acid (AA) degradation in stored dried mangoes can be described by a first order reaction. The effect of water activity and temperature on the rate constant for AA degradation can be modeled by a modified exponential equation. The activation energy for AA degradation in dried mangoes was almost constant at 65000 J/mole for water activity range of 0.65 to 0.85. The browning development in stored dried mangoes can be described by a zero order reaction. The effect of water activity and temperature on the rate constant for browning development can be modeled by a modified exponential equation. The activation energy for browning development in dried mangoes was almost constant at 57000 J/mole for water activity range of 0.65 to 0.85. The basis for shelf life prediction in dried mangoes was ascorbic acid degradation since acid degradation since this gave shorter shelf lives as compared with browning development. The shelf lives of dried mangoes decreased with increasing storage temperatures and sample water activity.

Keywords: intermediate moisture foods (IMF), dried mangoes, temperature, water activity, ascorbic acid, browning, rate constant, activation energy, shelf life

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INTRODUCTION

Most developing countries have tropical climate resulting in abundance of fruits such as mangoes, pineapples, bananas and many others. During the harvest season of these fruits, some are wasted due to abundant supply. Hence, these fruits have been processed into intermediate moisture foods (IMF). One of the most popular IMF from fruits is the intermediate moisture mango, sometimes also referred to as dried mangoes. One of the most popular variety of mangoes is the Manila or Philippine Mango because of its lush, sweet and delicious taste.

Intermediate moisture (IM) or dried mangoes contain two important vitamins namely vitamin C or ascorbic acid and vitamin A. About 40-42g of dried mangoes can supply about 30-50% of ascorbic acid and 2-30% of vitamin A of the recommended daily allowance (RDA) for Filipinos as claimed by several dried mango processors. Ascorbic acid is essential for healthy teeth gums and bones; builds strong body cells and blood vessels; and aids in healing wounds (Ensminger *et al*., 1983). However, ascorbic acid is a heat sensitive nutrient compared with vitamin A. Another quality factor in dried mangoes affected by long term storage is their color which deteriorate due to non-enzymatic browning reaction.

An extremely important aspect of IMF is their storage stability under different environmental conditions. The prediction of shelf life for these foods is essential for the food industry to provide an accurate estimate of nutrients during storage to meet the label claims. Besides nutrient losses, other quality factors of major concern for dried fruits could be microbial spoilage and non-enzymatic browning (Singh *et al*., 1983).

A number of environmental factors can affect the shelf life of IMF under storage. The two most important factors are storage temperature and relative humidity. The relative humidity of storage can affect the moisture content and hence the water activity of the product. It is therefore important to understand the kinetics and mechanism of quality deterioration in relation to storage temperature and water activity of the product, hence this study.

The specific objectives of the study were to: a) obtain kinetic data on ascorbic acid degradation and browning development as a function of temperature and water activity for stored dried mangoes; b) develop mathematical models to describe the effect of temperature and water activity on the rate of quality losses in stored dried mangoes; c) determine the effect of water activity on the activation energy for ascorbic acid degradation and browning development in stored dried mangoes and d) obtain the shelf lives of dried mangoes based on ascorbic acid degradation and browning development at different storage conditions.

MATERIALS AND METHOD

Preparation of Samples

Nine kilograms of commercial dried mangoes from a Philippine supermarket were obtained. The products were about one month old from the date of manufacture. The samples were obtained from an airconditioned supermarket with an average temperature of about 23-25°C. The dried mangoes were packaged in thick polypropylene bags and were stored in a chiller (5°C) prior to use.

The dried mangoes were taken out from their individual plastic bags, put in one big container and thoroughly mixed. The initial water activity and moisture content of representative samples at 25°C were about 0.65 water activity and 16% (dry basis), moisture content, respectively. The samples were divided into 9 lots corresponding to the nine treatments consisting of three temperatures (25, 35 and 45°C) and three water activity levels (low, medium and high).

The initial water activity of the samples were used as the low level of water activity but were equilibrated in airtight containers at the required temperatures for 24 hours. For the medium and high water activity levels, the dried mangoes were soaked in distilled water for corresponding duration to

get the required moisture. The soaked samples were placed in airtight containers and stored in the required temperatures for 24 hours to equilibrate the moisture to the individual slices. After equilibration, five representative slices were obtained from the different treatments for water activity and moisture content measurements as mentioned below.

Water Activity Measurement

The water activity of the samples in each treatment was measured using the Rotronic Hygroskop BT-RS1 (Rotronic AG) that have been previously calibrated. The meter is capable of measuring water activity from 0.001 to 1.000 over a temperature range of 0.5 to 50°C. Five water activity measurements for each treatment were carried out.

Moisture Content Determination

The moisture contents of the samples in each treatment were determined using a Yamato Model DPF-41 vacuum oven (Yamato Scientific Co., Ltd.) at 70±1°C and 760 mm Hg of vacuum for 48 hours. All measurements were carried out in 5 replications.

Storage of Samples

After reaching the required water activity at specific temperature, about 50g samples were sealed in screw-capped glass jars and further sealed using parafilm "M" (American National Company) and placed in constant temperature cabinet (Tabai Mfg. Co., Ltd.) set at the required temperatures. Separate glass jars were used for samples for color measurements. Six samples in glass jars were stored for each treatment for the ascorbic acid determination. Samples were withdrawn from storage every 4 to 7 days at 45°C, 8 to 12 days at 35°C and 12 to 20 days at 25°C until all the samples were taken out. One glass jar was withdrawn at different duration from the different treatments and was immediately analyzed for its ascorbic acid content as outlined below. The samples for color measurements were also analyzed with the same frequency as in ascorbic acid determination as presented below.

Measurement of Ascorbic Acid

Extraction. About 6g of shredded samples was added with 18 ml of 5% metaphosphoric acid solution and were macerated using mortar and pestle to a homogeneous slurry. The mixture was centrifuged at 5000 rpm and 5°C (Kubota Model 7820) for 10 minutes. The liquid was decanted and filtered first using an ordinary filter paper and then through a 0.45 microns filter (Ekicrodisc 25 CR). Triplicate samples were prepared for measurements.

Chromatography. A high performance liquid chromatograph (HPLC) Hitachi Model L-6320 equipped with a pump and an injector, column oven (Hitachi Model L-7300) and an ultraviolet (UV) detector (Hitachi Model L 7400) were used. The detector signal was recorded on an integrator (Hitachi Model D-7500). The chromatographic column was a Gelpack GL-C610H-S 7.8 mm. i.d. x 300 mm (Hitachi, Ltd.). The eluent used was 0.3% metaphosphoric acid solution at a flowrate of 0.5 ml/min. The column oven temperature was set at 50°C. The UV detector was set at a wavelength of 250 nm. A 10 microliter of sample was injected into the system for measurement. The retention time and the peak area can be obtained from print-out of the integrator. The peak area corresponds to the concentration of ascorbic acid present in the sample solution.

Amount of Ascorbic Acid. Ascorbic acid standard solutions in 5% metaphosphoric acid (HPO_3) were prepared in various concentrations (0.5 to 10 mg AA/100 ml HPO_3 solution). The standard solution was injected into the HPLC and the corresponding peak area was obtained. Four replications were done at each concentration. A calibration curve was fitted on the data as shown below,

$$C_{AA} = 1.0072 \times 10^{-5} A_P \qquad (r^2 = 0.982) \qquad \text{- - - -} \quad (1)$$

where: C_{AA} = concentration of ascorbic acid (mg AA/100 ml HPO_3 solution)

A_P = peak area obtained from HPLC measurement

The calibration curve was used in the determination of the amount of ascorbic acid present in the samples analyzed using the HPLC.

Measurement of Non-enzymatic Browning Reaction

Sample Preparation. Three slices of samples from each treatment were selected visually based on the most yellow and least brownish color Two-cm diameter disc was cut at the center of the slices using a stainless steel cork borer The representative samples were monitored for their color using a color meter as described below throughout the duration of the experiments

Color Measurement. The color of the samples were measured using the Color and Color Difference Meter Model ND-101D (Nippon Denshoku Kogyo Co., Ltd.) by obtaining the Hunter L, a and b values A standard white plate was used to calibrate the instrument prior to use The color value of each sample disc was measured at both sides The side of the slice away from the seed was considered as dorsal side while the opposite side was the ventral side. The color of the samples for each treatment at various times was taken as the average of all the values obtained for both sides of the three sample discs.

Data Analyses

The amount of ascorbic acid retained at different storage time for a given temperature and water activity was converted to percentage of ascorbic acid retained (%AA) using the equation below,

$$\%AA = 100(AA_0 - AA_t)/AA_0 \quad \text{----------} \quad (2)$$

where: AA_0 = initial amount of ascorbic acid in sample (mg AA/ 100 g sample)

AA_t = amount of ascorbic acid in sample at time t (mg

AA/100 g sample)

The data for ascorbic acid retained at different storage time were fitted to a first order reaction regression (Villota and Hawkes, 1992) as shown below,

$$\ln (\%AA) = I_f - S_f t \qquad \text{----------(3)}$$

where: I_f = intercept of the first order reaction regression
S_f = slope of the first order reaction regression
= rate constant for the first order reaction (k_f)

The b value was used in describing the browning development of the samples in terms of browning index calculated using the equation below,

$$\%BI = 100(b_{max} - b_t)/b_0 \qquad \text{----------(4)}$$

where: %BI = percentage browning index of sample
b_{max} = initial b value of sample with maximum value
b_t = b value of sample at time t

The data for percentage browning index at different storage time were fitted to a zero order reaction regression (Villota and Hawkes, 1992) as shown below,

$$\%\,BI = I_z - S_z t \qquad \text{----------(5)}$$

where: I_z = intercept of the zero order reaction regression
S_z = slope of the zero order reaction regression
= rate constant for the zero order reaction (k_z)

Regression analyses were done on the rate constants for ascorbic acid degradation and browning development first as a function of A_w then the

resulting regression constants were further related to temperature. In the case where the regression constants do not show a definite trend with temperature, then the mean value for the three temperatures was used in the mathematical modeling.

The effect of temperature on the rate constants were fitted with the Arrhenius relationship (Villota and Hawkes, 1992) using the equation below,

$$\ln k = \ln k_0 - (E_a/R)(1/T) \qquad \text{----------(6)}$$

where: k = rate constant
k_0 = frequency or collision factor
E_a = activation energy
R = gas constant (8.31434 J/[mole.°K])
T = absolute temperature (°K)

Using regression analysis for ln k versus 1/T would yield the slope and intercept of the line which were used in deriving the frequency factor and activation energy.

The shelf life of a food product can be determined depending upon the order of the reaction (Labuza, 1984). For the first-order reaction as in ascorbic acid degradation in a food product,

$$t_s = \frac{\ln (A_a/A_0)}{-k_{AA}} \qquad \text{------(7)}$$

where: t_s = shelf life of food product
A_a = amount of ascorbic acid in food product that is still acceptable
A_0 = initial amount of ascorbic acid in food product

k_{AA} = rate constant for ascorbic acid degradation in food product

For zero-order reaction as in browning development in a food product,

$$t_s = \frac{B_a - B_0}{-k_{BD}} \quad \text{----------(8)}$$

where: B_a = browning index of food product that is still acceptable
B_0 = initial browning index of food product
k_{BD} = rate constant for browning development in food product

RESULTS AND DISCUSSION

Water Activity and Moisture Content of Dried Mangoes

The mean and 95% error bound for the water activity and moisture content of the equilibrated dried mangoes at different temperature are shown in Table 1. The results showed that moisture content of samples increased with water activity for all temperatures which is consistent with the theory of physical adsorption (Brunauer *et al.*, 1938). However, at a water activity of about 0.65, the amount of sorbed water at a given water activity increased with increasing temperature. This phenomenon is maybe due to exudation (leaching) of sugars which has been observed for a number of high sugar dried fruits such as raisins, currants, figs, prunes and apricots (Ayranci *et al.*, 1990; Tsami *et al.*, 1990; Saravacos *et al.*, 1986).

Ascorbic Acid Degradation in Stored Dried Mangoes

The degradation of ascorbic acid in stored dried mangoes was determined as a function of temperature and water activity (A_w). As mentioned earlier, the samples of dried mangoes were about one month old from the date of manufacture. Using the ascorbic acid data of the samples with $A_w = 0.65$ at 25°C, the original amount of ascorbic acid in the dried mangoes was extrapolated and found to be 35 mg AA/100 g sample.

However, the initial amount of ascorbic acid (AA) in the samples studied were lower due to some losses in the AA content of samples which occurred during the equilibration to the required water activity at different temperatures. The AA content of low Aw samples from 22 to 29 mg AA/100 g sample, for the middle Aw samples from 15 to 22 mg AA/100 g sample and for the high A_w samples from 13 to 16 mg AA/100g sample.. The differences in the initial amount of AA in samples with different water activities were due to the amount of moisture present in each sample (Table 1).

The amount of AA were converted to percentage of AA retatined and

Table 1. Mean and 95% error for the water activity and moisture content of the equilibrated dried mangoes

Temperature	Water Activity	Moisture Content (% dry basis)
25°C	0.651+0.010	15.72+0.98
	0.744 +0.003	22.34+1.07
	0.844+0.009	29.90+1.03
35°C	0.639+0.006	14.71+0.65
	0.733+0.004	22.71+0.63
	0.801+0.013	35.14+0.37
45°C	0.646+0.007	17.14+1.79
	0.783+0.004	39.23+1.54
	0.834+0.004	48.29+1.92

were plotted on semi-logarithmic scale as shown in Figure 1 for samples at 25°C and different A_w levels. The same behavior was also shown by the samples at 35°C and 45°C. All the plotted data appximated straight lines which greatly indicate that AA degradation in stored IM mangoes is a first order reaction. The results also show that the rate of AA degradation increase with temperature and A_w.

Hence, the data were fitted with the first order reaction regression and the results are summarized in Table 2. The coefficients of determination (r^2) for the different samples were above 0.95 which indicate the goodness of fit of the data. Various works have shown that AA degradation in IM fruits such as dried pineapple and apple follow a pseudo-first order kinetics (Pardio Sedas *et al.*, 1994; Singh *et al.*, 1983).

Linear, logarithmic and exponential regressions were fitted on the rate constant for AA degradation as a function of water activity at specific temperatures. The results show that the exponential regression equations gave consistently higher r^2 values at all temperatures than the other equations. Analysis of the exponential regression constants indicated that the intercept can be linearly related to temperature giving a very high r^2=1.000. But the slope did not show a definite trend with respect to temperature which gave a mean value of 5.60188. Hence an equation relating the AA degradation rate constant to temperature and water activity was obtained as shown below,

$$k_{AA} = 10^{-1.883+0.0358T_c} A_W^{5.602} \quad \text{----------(9)}$$

where : k_{AA} = rate constant for AA degradation in IM mangoes (day^{-1})

T_c = temperature (°C)

Using equation 9, the predicted rate constants were calculated and

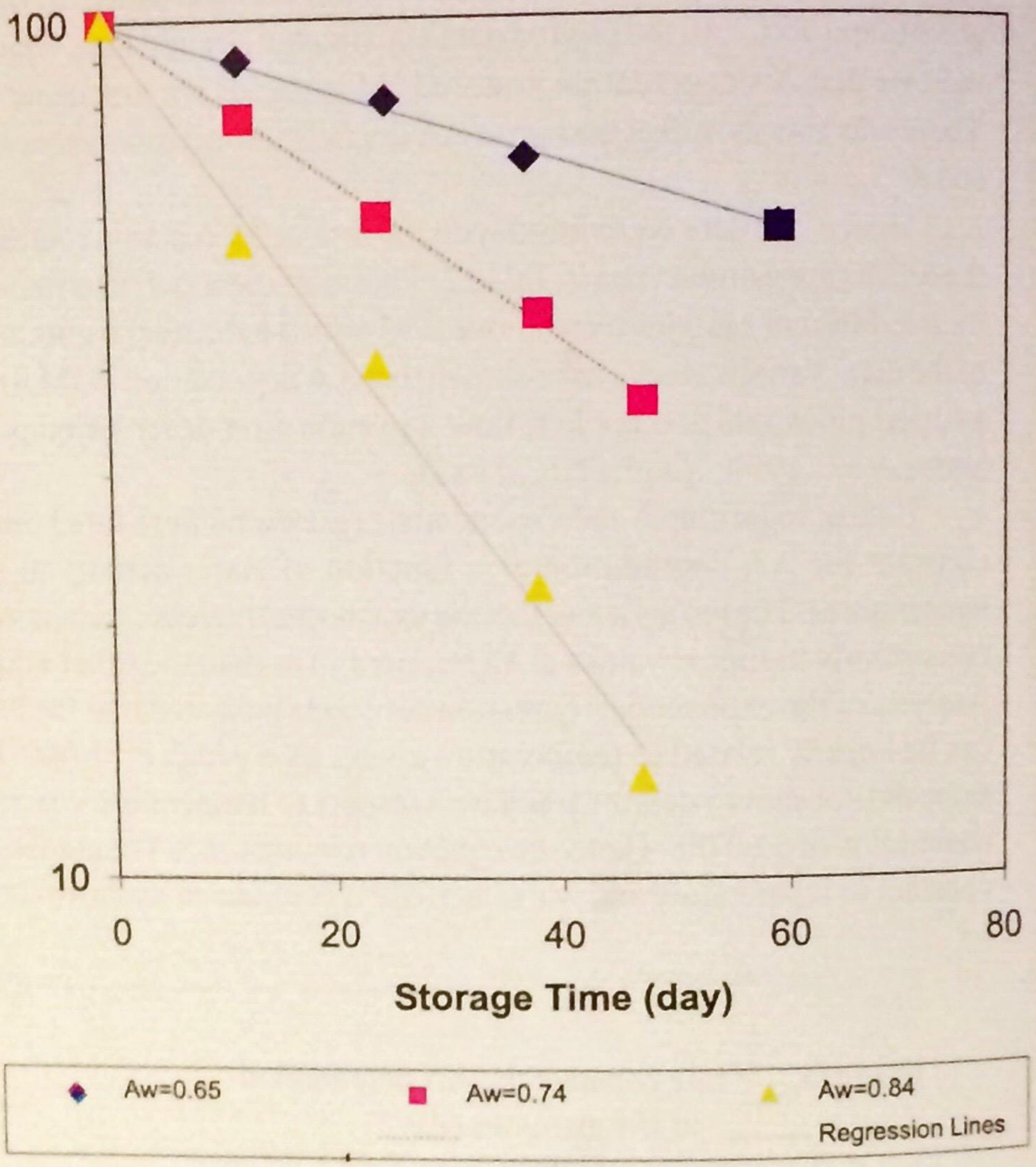

Figure 1. Ascorbic acid degradation in stored dried mangoes at 25°C.

Table 2. First order reaction regression for AA degradation in stored dried mangoes

Temperature	A_w	Intercept	Slope/rate Constant (day $^{-1}$)*	r^2
25°C	0.65	4.61180	-0.009339	0.995
	0.74	4.60667	-0.021039	0.998
	0.84	4.60179	-0.041301	0.990
35°C	0.64	4.65122	-0.019423	0.995
	0.73	4.61596	-0.041648	0.997
	0.80	4.73484	-0.066654	0.979
45°C	0.65	4.71365	-0.046803	0.951
	0.78	4.82965	-0.146886	0.965
	0.83	4.69533	-0.175386	0.983

* negative sign refer to the decreasing amount of ascorbic acid over time

compared with the experimental rate constants as shown in Table 3. The mean percentage difference forthe nine treatments was about 5% which suggest that the derived equation is very adequate for prediction of the rate constants.

Again using equation 9, the rate constants for AA degradation at different temperatures and constant water activities were obtained. Using these data, the effect of temperature on the rate constants for ascorbic acid degradation at specific water activity was determined using the Arrhenius relationship. The results of the Arrhenius regression and the resulting activation energy are shown in Table 4. The results indicate that the Arrhenius model fitted the data well as shown by their high r^2 values.

The mean and 95% error bound of activation energy for AA degradation in dried mangoes was almost constant at 65000 J/mole for water activity range of 0.65 to 0.85. The values were very close to the activation energy for AA degradation in dried apples which varied from 59000 to 68000 kJ/kg.mole for a water activity range of 0.62 to 0.89 (Singh *et al.*, 1983). However, the trend of activation energy with respect to water activity for the work of Singh *et al.* (1983) was not the same as this study. The results show the activation energy for AA degradation in IM mangoes fluctuated slightly with no definite

trend. Villota and Hawkes (1992) also found no definite trend for AA degradation in rehydrated tomato juice powder and beef model food system.

Table 3. Experimental and predicted rate constants (k) for AA degradation in stored dried mangoes

Temperature	A_w	Experimental k (day $^{-1}$)	Predicted k (day $^{-1}$)	%Difference
25°C	0.65	0.0093	0.0092	1.48%
	0.74	0.0210	0.0190	9.5%
	0.84	0.0413	0.0387	6.31%
35°C	0.64	0.0194	0.0192	0.99%
	0.73	0.0146	0.0402	3.51%
	0.80	0.0667	0.0671	0.71%
45°C	0.65	0.0468	0.0478	2.17%
	0.78	0.1469	0.1328	9.60%
	0.83	0.1754	0.1881	7.23%
			Mean	4.62%

Browning Development in Stored Dried Mangoes

The browning development in stored dired mangoes was determined as a function of temperature and A_w. It was found that dried mangoes with above 30% browning index were no longer acceptable with respect to its color. The percentage of browning index at different storage time were plotted on arithmetic scale as shown in Figure 2 for 25°C samples at different A_w levels. The same behavior was also exhibited by the samples at 35°C and 45°C. The data were fitted with the zero order reaction regression and the results are summarized in Table 5. The r^2 values for the different samples were above 0.97 which indicate the goodness of fit of the data. The zero order kinetics for browning development in dehydrated foods has been often reported in the

Table 4. Arrhenius regression and activation energy for AA degradation in stored dried mangoes

A_w	Intercept	Slope	r^2	E_a (J/mole)
0.650	21.50730	-7812.73	1.000	64958
0.675	21.68427	-7801.91	1.000	64868
0.700	21.96033	-7824.66	1.000	65057
0.725	22.09728	-7805.75	1.000	64900
0.750	22.32163	-77816.67	1.000	64990
0.775	22.52631	-7823.33	1.000	65046
0.800	22.69424	-7820.32	1.000	65021
0.825	22.83775	-7811.25	1.000	64945
0.850	23.03232	-7819.74	1.000	65016
		Mean $\pm$ Error Bound		64978$\pm$63

literature (Singh *et al.*, 1983; Labuza, 1981; Resnick and Chirife, 1979; Schnickels *et al.*, 1976).

Similar regression analyses as in AA degradation were also done on the rate constants for browning development as a function of water activity at specific temperatures. The results show that the exponential regression equations also gave consistently higher r^2 values at all temperatures. The exponential regression constants were related to temperature to obtain equations that would best describe the constants. Hence an equation relating the browning development rate constant to temperature and water activity was obtained a shown below,

$$k_{BD} = 10^{-0.673+0.0316Tc} \quad A_W^{4.900} \quad \text{----------(10)}$$

where: k_{BD} = rate constant for browning development in IM mangoes (%BI/day)

Using equation 10, the predicted rate constant were calculated and compared with the experimental rate constant a shown in Table 6. The mean percentage difference for the nine treatments was about 7% which suggest that the derived equation is very adequate for prediction of the rate constants.

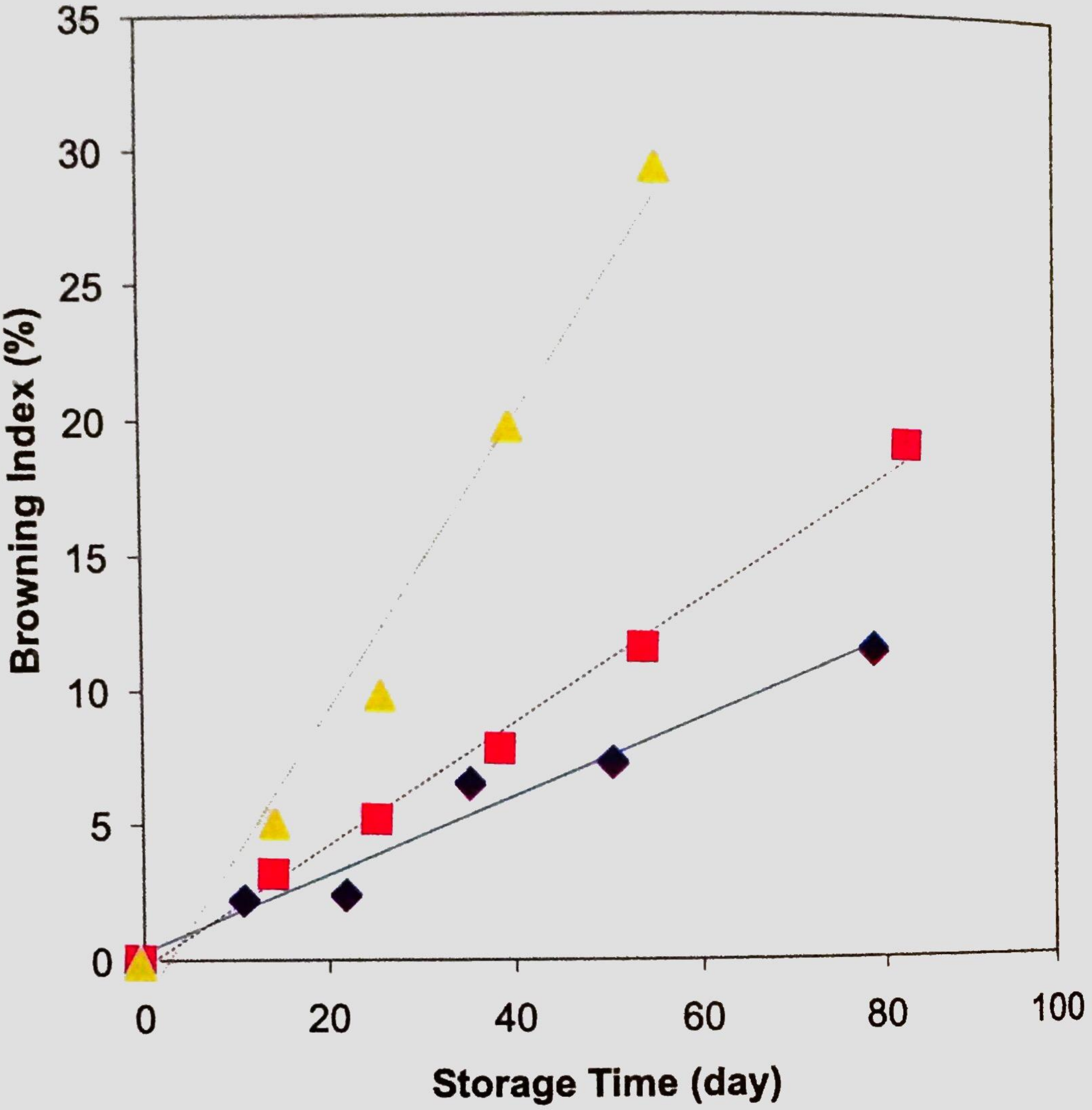

Figure 2. Browning development in stored dried mangoes at 25°C .

Table 5. Zero order reaction regression on browning development in stored dried mangoes

Temperature	A_w	Intercept	Slope/Rate Constant (% BI/day)	r^2
25°C	0.65	0.173	0.156	0.973
	0.74	-0.396	0.244	0.995
	0.84	-1.850	0.581	0.980
35°C	0.64	-0.300	0.365	0.999
	0.73	1.127	0.570	0.985
	0.80	0.810	1.030	0.981
45°C	0.65	0.025	0.647	0.996
	0.78	0.905	1.638	0.985
	0.83	-0.321	2.194	0.997

Again using equation 10, the rate constants for browning development at different temperatures and constant water activites were obtained. Using these data, the effect of temperature on the rate constants for browning development at specific water activity was determined using the Arrhenius relationship. The results of the Arrhenius regression and the resulting activation energy are shown in Table 7. The results indicate that the Arrhenius model fitted the data well as shown by their high r^2 values.

The activation energy for browning development in stored dried mangoes was almost constant at 57000 J/mole for water activity range of 0.65 to 0.85. The values were much lower than the activation energy for browning development in dried apples which varied from 80000 to 135000 J/mole for a water activity range of 0.62 to 0.89 (Singh *et al.*, 1983). This means that browning development in dried mangoes is more temperature sensitive than in dried apples. The trend of activation energy with respect to water activity for the work of Singh *et al.* (1983) was also different from this study. The results obtained show that the activation energy for browning development in dried mangoes increased with water activity which suggest that there are probably other factors that affected the activation energy in stored dried mangoes. The

Table 6. Experimental and predicted rate constants (k) for browning development in stored dried mangoes

Temperature	A_w	Experimental k (day $^{-1}$)	Predicted k (day $^{-1}$)	% Difference
25°C	0.65	0.156	0.158	1.28%
	0.74	0.244	0.299	22.54%
	0.84	0.581	0.557	4.13%
35°C	0.64	0.365	0.304	16.71%
	0.73	0.570	0.579	1.58%
	0.80	1.030	0.907	11.94%
45°C	0.65	0.647	0.678	4.79%
	0.78	1.638	1.657	1.16%
	0.83	2.194	2.247	2.42%
			Mean	7.39%

differences in the results obtained with that of Singh *et al* (1983) might be due to the method of preparation of the samples. Dried mangoes are artificially sweetened with sugar which probably affected the browning development of samples.

Shelf Life Prediction of Dried Mangoes

Using equations 7 and 8, the shelf lives of dried mangoes can be calculated based on ascorbic acid degradation and browning development, respectively. The rate constants for ascorbic acid degradation at temperatures of 25, 30 and 35°C and A_w from 0.65 to 0.85 were calculated using equation 9. While the rate constants for browning development at temperatures of 25, 30 and 35°C and A_w from 0.65 to 0.85 were calculated using equation 10. The shelf lives of dried mangoes were calculated based on the assumption that the minimum acceptabl ascorbic level in dried mangoes was 25% of its original value and the maximum acceptable browning index in dried mangoes was 30% from an initial value of 0%. Table 8 presents the predicted shelf lives of dried mangoes at different temperatures and water activites based on ascorbic

Table 7. Arrhenius regression and activation energy for browningdevelopment in stored dried mangoes

A_w	Intercept	Slope	r^2	E_a (kJ/kg.mole)
0.650	19.52036	-6905.90	0.999	57418
0.675	20.11204	-6884.61	0.999	57241
0.700	20.67001	-6889.18	0.999	57279
0.725	21.29606	-6885.69	0.999	57250
0.750	21.82955	-6899.41	0.999	57364
0.775	22.83514	-6896.40	0.999	57339
0.800	22.92613	-6896.88	0.999	57343
0.825	23.41264	-6889.42	0.999	57281
0.850	23.92076	-6893.03	0.999	57311
			Mean ± Error Bound	57314±48

acid degradation and browning development.

The results show that the basis for shelf life prediction in dried mangoes was ascorbic acid degradation since this gave shorter shelf lives as compared with browning development. In addition, the shelf lives of dried mangoes decrease with increasing storage temperatures and sample water activities for both ascorbic acid degradation and browning development. hence, for a storage temperature of 30°C and the sample $A_w = 0.65$, the shelf life of dried mangoes will be 100 days or about 3 months. However, if both the storage temperature and the sample A_w increase then the shelf life will be much shorter. But if the dried mangoes were stored in an air conditoned room such as in supermarkets then the shelf life will be longer.

CONCLUSIONS

The moisture content of dried mangoes increased with water activity for all temperatures which is consistent with the theory of physical adsorption. However, at a water activity of about 0.65, the amount of sorbed water at a given water activity increased with increasing temperature.

The AA degradation in stored dried mangoes can be described by a first order reaction. The effect of water activity and temperature on the rate constant for AA degradation can be modeled by a modified exponential equation. The

Table 8. Predicted shelf lives of dried mangoes at different temperatures and water activities based on ascorbic acid degradation and browning development

Temperature (°C)	Water Activity	Shelf Life (days)	
		Ascorbic Acid Degradation	Browning Development
25	0.65	151	189
	0.70	100	132
	0.75	67	94
	0.80	47	68
	0.85	34	51
30	0.65	100	131
	0.70	66	91
	0.75	45	65
	0.80	31	48
	0.85	22	35
35	0.65	66	92
	0.70	44	64
	0.75	30	45
	0.80	21	33
	0.85	15	25

mean activation energy for AA degradation in dried mangoes was almost constant 65000 J/mole for water activity range of 0.65 to 0.85.

The browning development in stored dried mangoes can be described by a zero order reaction. The effect of water activity and temperature on the rate constant for browning development in stored dried mangoes was almost constant at 57000 J/mole for water activity range of 0.65 to 0.85.

The basis for shelf life prediction in dried mangpoes was ascorbic acid degradation since this gave shorter shelf lives as compared with browning development at the same storage conditions. The shelf lives of dried mangoes decrease with increasing storage temperatures and sample water activities.

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