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Note: APETT’s logo was designed by Derek Aleong.

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Editorial

I. Notes from the Editors

The APETT Journal aims to provide a broad coverage of subjects relating to engineering. Preference will be given to papers describing original engineering work, or material of specific interest to engineers and those working in related fields, in Trinidad and Tobago (T&T) and the Caribbean region.

II. About This Issue

This Issue (Volume 46 Number 2) of the Journal includes five (5) articles and a memorial written for the late Eur Ing Aldwyn Lambert Lequay who was the past President of APETT (1976-1977). The relevance and usefulness of these articles are summarised below.

C. Greene and **K.F. Pun,** "Introduction of Project Management Maturity Assessment to Plant Outages and Turnarounds at Petrochemical Process Plants in a Caribbean Island Economy", present a case study on assessing the challenges and identifying improvements of project management (PM) practices for plant outages and turnarounds at petrochemical process plants in Trinidad and Tobago. Personal interviews and assessment questionnaires along with the maturity scale developed were used to determine the staff's extent of PM knowledge and the maturity level of the company's PM practices. Incorporated are the empirical findings with desk research, a project management maturity (PMM) approach which could be tailored and its core components and building blocks identified. Further work would validate the use of PMM approach in managing plant outages and turnarounds in the petrochemical sector in T&T and the wider Caribbean region.

Based on their work, "Effective Moisture Diffusivity and Activation Energy Estimation of Cucumber Fruit Slices Using a Refractance Window^{TM} Dryer", **A.A. Akinola, et al.** investigate into the effective moisture diffusivities and the activation energy of cucumber fruit slices with respect to the effect of temperature on the drying kinetics. A laboratory scale Refractance Window^{TM} dryer was used to obtain dehydration data for cucumber fruit slices. Experiments carried out on cucumber fruit slices with water temperatures in the dryer at 65^{o}C (338K), 75 ^{o}C (348K) and 85 ^{o}C (358K) were performed. The experimental drying data were fitted to 8 thin layer drying models to select the most appropriate drying model. The Haghi and Ghanadzadeh model was determined to be the most suitable for the process conditions studied. Fick's second law was used to calculate the effective moisture diffusivity. The activation energy was estimated using the Arrhenius equation and for the given temperature range. The results aid in understanding the design, analysis, and optimisation of such equipment for the drying of food.

In their paper, "Kinetics Models Validation, Conversion and Estimation of Catalyst Dose for Biodiesel Synthesis in a Packed Bed Reactor", R.U. Owolabi, M.A. Usman and O.A. Gegeleso, investigated the catalytic trans-esterification reaction of ethanol and palm oil between 25-55 ^{o}C for the chemical reaction kinetics of large scale production of biodiesel. The trans-esterification reaction were tested using second order kinetics both reversible and irreversible and first order kinetics model. The reaction conformed well with the irreversible second order kinetic model. The maximum yield of 97.19% was obtained from the highest reaction temperature considered. This further extended existing theories on reaction rates, yield and temperature.

M.M. Arjoon *et al.*, "A Channel to Demonstrate the Effect of Width, Slope and Bed Roughness on Water Flow", describe the design, construction and testing of an open channel with a variable slope and width used to demonstrate water flow rates in the laboratory. Results showed that width of the channel was the most important factor influencing water flow rates followed by channel bed roughness and the slope in that order. There was a significant interaction between the factors of channel width and slope, on the water flow rates. Multiple regression equations that related water flow rates measured using both methods (velocity meter and the weir) to the experimental factors produced values of coefficients of determination that were very significant. The novelty of this design is that this variable width channel could be used to demonstrate the major factors that affect water flow rates in channels since these factors could be adjusted within the same set-up.

A. Koonj-Beharry and K.F. Pun, "Exploring Diversification Competitiveness of Caribbean Manufacturers: Some Thoughts", explores the need of attaining diversification competitiveness, and discusses the contribution to Gross Domestic Product (GDP) of the Caribbean Manufacturing Sector, with particularly reference to four selected nations, Barbados, Guyana, Jamaica, and Trinidad and Tobago (T&T) spanning a period of two decades from 1996 to 2016. It then shares some thoughts on assessing the competitiveness and innovation capability of Caribbean manufacturers, and suggests areas for future work.

C.A.C. Imbert, "Ing Aldwyn Lambert Lequay (1927-2018): A Memorial", speaks about the profession life, and recognises the commitments and contributions of late Eng Ing Aldwyn Lambert Lequay towards the development of mechanical and electrical engineering disciplines and professionals in Trinidad and Tobago and the wider Caribbean region.

III. Acknowledgements

On behalf of the Association, we gratefully acknowledge all authors who have made this issue possible with their research work. We greatly appreciate the voluntary contributions and unfailing support that our reviewers give to the Journal. Our reviewer panel is composed of academia, scientists, and practising engineers and professionals from industry as listed below:

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Effective Moisture Diffusivity and Activation Energy Estimation of Cucumber Fruit Slices Using a Refractance Window^{TM} Dryer

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Abstract: *This paper presents an estimation of the effective moisture diffusivities and the activation energy of cucumber fruit slices by studying the effect of temperature on the drying kinetics. A laboratory scale Refractance Window^{TM} dryer was used to obtain dehydration data for cucumber fruit slices. Experiments carried out on 3 mm thick cucumber fruit slices with water temperatures in the dryer at 65 ^{o}C (338K), 75 ^{o}C (348K) and 85 ^{o}C (358K) were performed. The experimental drying data were fitted to 8 thin layer drying models to select the most appropriate drying model. The Haghi and Ghanadzadeh model was determined to be the most suitable for the process conditions studied. Fick's second law was used to calculate the effective moisture diffusivity. The moisture diffusion coefficient varied between 1.94 x 10^{-9} m^2s^{-1} and 2.54 x 10^{-9} m^2s^{-1} for the process conditions studied. The activation energy was estimated using the Arrhenius equation and for the given temperature range. The corresponding activation energy was calculated to be 13.55kJ/mol. A knowledge of the effective moisture diffusivities and activation energy of the cucumber fruit slices, when determined using the Refractance Window^{TM} drying technique will aid in understanding the design, analysis, and optimisation of such equipment for the drying of food.*

Keywords: *Refractance Window^{TM} Drying; Effective Moisture Diffusivity; Activation Energy; Drying Kinetics; Cucumbers*

1. Introduction

Cucumbers are members of the botanical family *Cucurbitaceae*, cucumbers (*C. sativus*). The cucumber fruits are made up of 95 percent water; they are naturally low in calories, fat, cholesterol, and sodium (Metaljan, 2015). The nutritional composition per 100g of raw sliced cucumbers, is as follows, 17.06 mcg vitamin K, 5.20 mcg molybdenum, 0.27 mg pantothenic acid, 0.04 mg copper and 152.88 mg potassium. They also have 0.08 mg manganese, 2.91 mg vitamin C, 24.96 mg phosphorus,13.52 mg magnesium, 0.94 mcg biotin and 0.03 mg vitamin B1(Suchankova *et al*., 2015; USDA, 2017).

Although cucumbers are a great addition to salads when eaten, they have other benefits when used on the skin and hair. Cucumbers also have health benefits. Drinking cucumber juice is known to reduce hair loss, and when used to rinse hair, it gives it a silky and shiny color (Rahi, 2017). The greatest and most significant skin benefit of cucumber is that it aids in revitalising the skin. Cucumbers are mild astringents that help in getting rid of a skin tan (Rahi, 2017). The daily consumption of cucumbers is considered to be an effective laxative; it relieves constipation. Cucumbers are also known to help treat problems arising in the urinary system.

Cucumbers, however, are seasonal fruits that need to be preserved for their availability all year round. Drying is a widely used method of preserving cucumbers. It is important to know some physical characteristics of the product such as moisture diffusivity, activation energy and the drying characteristics for design calculations and modeling of dryers.

Although moisture diffusivity data exist in the literature (Bruin *et al.*, 1980; Chirife, 1983; Gekas, 1992; Marinos-Kouris and Maroulis,1995, Zogzas *et al*., 1996), moisture diffusivity data for foodstuff, which can be used for equipment design are scarce for a few reasons. There are diverse experimental methods of determining it; there are different methods of analysing moisture diffusivity. There are also, variations in composition and structure of the foodstuff whose moisture diffusivities are required (Panagiotou *et al*., 2004).

The Refractance Window^{TM} drying apparatus was used in the study. The method and apparatus was patented by Magoon (1986) and developed by MCD Technology Inc., Tacoma, WA, USA (MCD, 2000). The Refractance Window^{TM} drying apparatus employs a novel drying technique in which the fresh food product is spread on a transparent plastic film. Hot water heats the plastic film, and the heat from the plastic film dehydrates the food product placed on it. A detailed explanation of the Refractance Window^{TM} drying technique is provided in literature (Abonyi *et al.*, 1999; Bolland, 2000; Clarke, 2004; Nindo and Tang, 2007).

The objectives of this work are to estimate the moisture diffusivities over a temperature range and also to estimate the activation energy value of cucumber fruit slices. Moisture diffusivity and activation energy are important parameters that are considered essential to optimisation, modeling and designing of drying processes for food, aro-products and other materials (Chayjan *et al.*, 2013; Joardder *et al.*, 2014).

2. Methods and Materials

2.1 Sample preparation and the Drying Unit

Fresh cucumber fruits were bought from a local market in Lagos, Nigeria, a tropical city at longitude 6.6080° N and latitude, 3.6218° E. The cucumber fruits were cylindrical, but elongated with tapered ends. They had lengths varying between 20.0 to 23.5 cm and diameters between 4.5 cm to 5.8 mm. The cucumber fruits were washed, peeled, and cut into 3.0 mm thick circular slices using a mandolin slicer. Using an OHAUS MB45 moisture content analyser (OHAUS, 2011), the initial moisture content value of the cucumber fruits was determined to be 22.20 $\pm$ 0.16 g-water/g-solid cucumber.

A laboratory scale Refractance window dryer, presented in Fig. 1, was used in this study. The apparatus consists of a water bath covered with a 0.15 mm thick transparent polyethylene terephthalate (PET) Mylar plastic film. Metal brackets were used to hold the film in place, and the film was always in contact with the water. The water in the bath was heated using a thermostatically controlled electric immersion heater. The drying surface remained exposed to ambient air, and a draft of air maintained across the surface. Also, the dryer had an extractor above it from which the moist air above the drying surface was removed. The draft of air and the extractor was used to reduce the humidity above the dryer and ensure that the moist air did not inhibit the drying process.

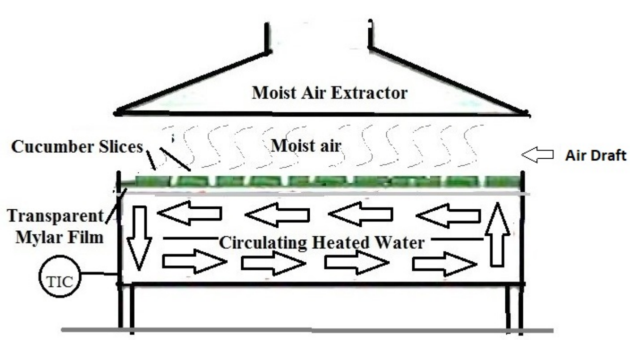

Figure 1. A Schematic Diagram of a Refractance Window Dryer

2.2 Drying Experiments

The drying experiments were performed with the heating water in the Refractance Window^{TM} dehydrator at 65^{o}C (338K), 75 ^{o}C (348K) and 85 ^{o}C (358K) respectively. The afore-mentioned temperatures were chosen for two reasons. First, a temperature range was required because this study is to be done over a temperature range. Second, a temperature of 65^{o}C was selected as this was considered a minimum temperature in which the drying process will not be too long. Also, a maximum temperature of 85^{o}C was chosen as this was considered a temperature in which the cucumbers will not stick to the drying plastics during dehydration. A higher temperature could have been considered, but it was found the cucumber stock to the plastic film. The 75^{o}C temperature is the mean between the minimum and maximum selected temperature.

The 3.0 mm, thick cucumber fruit slices, were placed on the transparent PET plastic on the dryer, and at 5 - minute intervals, some slices were removed and their moisture content determined. Each experiment was performed three (3) times. Estimation of the equilibrium moisture content was achieved by continuing the dehydration operations for up to 240 minutes. The samples were removed and exposed to ambient air in the laboratory for 24 hours. The moisture content of the samples was then measured.

2.3 Mathematical Modelling and the Drying Models

The moisture ratio *(MR)* was determined using Equation 1. The experimental data were fitted to 8 common thin-layer drying models used in the dehydration of fruits and vegetables. Presented in Table 1 are the thin-layer models used for this study.

$$MR = MC_t - MC_e / MC_i - MC_e \qquad (1)$$

where, MC_t is the moisture content of the sample after drying for time t; MC_e is the equilibrium moisture content of the sample, and MC_i is the initial moisture content of the fresh sample, all in the unit of grams of water removed/grams of solids.

Table 1. Thin-layer drying models used for this study

S/N	Model
1	MR = a.exp (-b.t^{c}) + d.t^{2} + e.t + f Haghi and Ghanadzadeh Model (Haghi and Ghanadzadeh, 2005)
2	MR = a*exp(-k*(t)^n)+(b*t) Midilli and Kucuk Model (Midilli and Kucuk, 2003).
3	MR =exp (−k.t^{n}) Page Model (Page, 1949)
4	MR =a.exp (-k.t) Henderson and Pabis Model (Henderson and Pabis, 1961)
5	MR = exp(-k(t/L^{2})^{n}) Modified Page equation –II (Diamante and Munro, 1993)
6	MR = exp (-k.t) Newton Model (Ayensu, 1997)
7	MR =a.exp (-k.t) + c Logarithmic Model (Toğrul and Pehlivan, 2003)
8	MR = a.exp (-k.t) + (1-a).exp (-k.b.t) Diffusion Approach Model (Demir *et al.*, 2007)

where, *MR* is the moisture ratio
t is the drying time and,
a, b, c, d, e, f, k, k_0, k_1, k_2 and n are all constant determined by regression analysis.

2.4 Modeling of Drying Kinetics

The experimental drying data were fitted to the equations in Table 1, to determine the thin-layer drying model that best describes the drying kinetics of the cucumber slices. The selection criteria were based on estimating the coefficient of determination (R^2), the sum-of-squares-error (SSE), and the root-mean-square-error (RMSE). For quality fit, R^2 should be the closest to unity while SSE and RMSE should be the closest to zero. The methods of estimating R^2, SSE and RMSE are already discussed generally and extensively in literature (Ogunnaike, 2011; Johnson, 2017).

However, Ertekin and Yaldiz, (2004), Kabiru *et al.*, (2013), and Akinola *et al.*, (2016) have used these techniques in the kinetic studies of roots, fruits, and vegetables. The Polymath 6.1 software was used to perform the statistical analysis (Polymath, 2016; Cutlip *et al.*, 2008). A moisture ratio against drying time plot (drying curve), was drawn, after obtaining the best thin-layer drying model, that fit the drying data.

2.5 Determining the Effective Moisture Diffusivity and the Activation Energy

The effective moisture diffusivity, D_{eff} , was estimated using Fick's law second equation of diffusion. Fick's law as proposed by Crank (1975) expresses the relations between moisture ratio, *MR*, and effective moisture diffusivity as presented in Equation 2.

$$MR = \frac{8}{\pi^2}\exp(-\frac{\pi^2 D_{eff} t}{4L^2}) \quad (2)$$

where,

MR is the moisture ratio,
D_{eff} (m^2s^{-1}) is the effective moisture diffusivity,
L (m) is the sample thickness and
t is the drying time (s).

However, the following assumptions were made (Sharma *et al.*, 2005). The moisture in the samples was distributed uniformly throughout the mass, the surface moisture content of the samples reached equilibrium instantaneously with the condition of surrounding air, resistance to the mass transfer at the surface of the slices was negligible compared to the internal resistance of the sample, and the diffusion coefficient was constant. A detailed discussion of these assumptions can be found in Sharma *et al.* (2005), Jena and Das (2007), and Taheri-Garavand *et al.*, (2011).

A plot of $-ln(MR)$ against time gives a slope of k_d, from which D_{eff}, could be obtained according to the Equation 3.

$$k_d = \frac{\pi^2 D_{eff}}{4L^2} \quad (3)$$

The activation energy was calculated by using an Arrhenius type equation (Lopez *et al*., 2000; Akpinar *et al*., 2003):

$$D_{eff} = D_0 e^{\left(\frac{-E_a}{RT}\right)} \quad (4)$$

where,

E_a is the energy of activation (J/mol),
R is universal gas constant (8.314 J/mol),
T is absolute air temperature (K), and
D_{eff} (m^2s^{-1}) is the effective moisture diffusivity, and
D_0 is the pre-exponential factor of the Arrhenius equation (m^2/s).

The activation energy can be determined from the slope of the Arrhenius plot, -ln(D_{eff}) against 1/T. A plot of –ln(D_{eff}) against 1/T gives a slope of k_r from which E_a can be obtained according to the Equation. 5

$$k_r = E_a / R \quad (5)$$

where k_r is determined by linear regression analysis of the data points

3. Results and Discussion

3.1 Experimental Environment

The drying experiments were carried out with the upper surface of the transparent plastic film on which the slices were placed, exposed to ambient air. The ambient air conditions in the laboratory had humidity values which varied from 51 to 60%, and room temperature values from 29 to 31°C.

3.2 Fitting of Experimental Data to Mathematical Models

For the experiments performed, the initial moisture content of cucumber slices was 22.20 g-water/ g-solid cucumber. The drying processes were stopped when the moisture content was about 0.11 g-water/ g-solid cucumber. The experimental moisture content data, on a dry basis, obtained during the drying experiments were converted into the moisture ratio (*MR*) and fitted to the 8 thin-layer drying models listed in Table 1. Presented in Tables 2, 3, and 4 are the statistical parameters of the tested models fitted to the experimental data.

The model chosen to best fits the drying kinetics of the cucumber slices is the one whose R^2 is closest to unity, and SSE and RSME are closest to zero. Observations indicate that the experimental data fit all the models with R^2 values better than 0.98, and SSE and RSME values close to zero. However, the Haghi and Ghanadzadeh (2005), thin-layer drying model is observed to be the best to fit the experimental data in all 3 cases.

Table 2. Statistical Parameters of the Models Fitted to the Experimental Data at 65°C

Temperature		65 °C (338K)		
S/N	Model	R^2	SSE	RSME
1	Haghi and Ghanadzadeh Model	0.9923	0.0140	0.0316
2	Midili and Kucuk Model	0.9840	0.0302	0.0434
3	Henderson and Pabis Model	0.9840	0.0302	0.0421
4	Page Model	0.9800	0.0377	0.0458
5	Modified Page II Model	0.9800	0.0377	0.0458
6	Diffusion Approach Model	0.9792	0.0393	0.0481
7	Logarithmic Model	0.9722	0.0525	0.0556
8	Newton Model	0.9623	0.0713	0.0612

Table 3. Statistical Parameters of the Models Fitted to the Experimental Data at 75°C

Temperature		75°C (348K)		
S/N	Model	R^2	SSE	RSME
1	Haghi and Ghanadzadeh Model	0.9993	0.0010	0.0110
2	Midili and Kucuk Model	0.9991	0.0011	0.0107
3	Henderson and Pabis model	0.9989	0.0014	0.0113
4	Page Model	0.9989	0.0014	0.0108
5	Modified Page II Model	0.9989	0.0014	0.0108
6	Diffusion Approach Model	0.9985	0.0019	0.0131
7	Logarithmic Model	0.9840	0.0208	0.0435
8	Newton Model	0.9801	0.0259	0.0446

Table 4. Statistical Parameters of the Models Fitted to the Experimental Data at 85°C

Temperature		85°C (358K)		
S/N	Model	R^2	SSE	RSME
1	Haghi and Ghanadzadeh Model	1.0000	0.0000	0.0011
2	Midili and Kucuk Model	0.9996	0.0004	0.0076
3	Henderson and Pabis Model	0.9992	0.0008	0.0100
4	Page Model	0.9992	0.0008	0.0095
5	Modified Page II Model	0.9992	0.0008	0.0095
6	Diffusion Approach Model	0.9670	0.0345	0.0657
7	Logarithmic Model	0.9684	0.0330	0.0643
8	Newton Model	0.9670	0.0345	0.0587

For the Haghi and Ghanadzadeh model, the R^2, SSE and RSME values are 0.9923, 0.0140, 0.0316 when the bath water was at 65°C, 0.9993, 0.0010, 0.0110 when the bath water was at 75°C, and 1.0000, 0.0000, 0.0011when the bath water was at 85°C. Table 5 shows the model constants obtained for Haghi and Ghanadzadeh model.

Table 5. Model Constants Obtained Fitting Experimental Data to the Haghi and Ghanadzadeh Thin-layer Models

Model Name	65°C (338K)	75°C (348K)	85 °C (358K)
Haghi and Ghanadzadeh	a = 0.4864	a = 1.113	a = 0.9683
	b = 0.0003137	b = 0.01127	b = 0.002098
	c = 2.047	c = 1.434	c = 2.474
	d = 2.075e-05	d = -1.217e-05	d = 2.824e-06
	e = -0.00603	e = 0.002462	e = -0.0005553
	f = 0.4288	f = -0.1139	f = 0.03173

The selection of the Haghi and Ghanadzadeh (2005) thin-layer drying model as the best fit for the drying kinetics was further validated by plotting the values of the experimental moisture ratio (EMR) against the predicted moisture ratio (PMR) (see Figure 2). Table 6 presents the equations for the relationship and the coefficient of variance (R^2) values for each temperature. Clearly, the experimentally determined moisture ratio and the predicted moisture ratio for the 3.0 mm thick cucumber slices do not vary significantly.

3.3 Moisture Ratio and Drying Time Relationship

A plot of the moisture ratio against drying time is shown in Figure 3. The plot shows that moisture ratio decreased continuously with drying time. At bath water temperatures

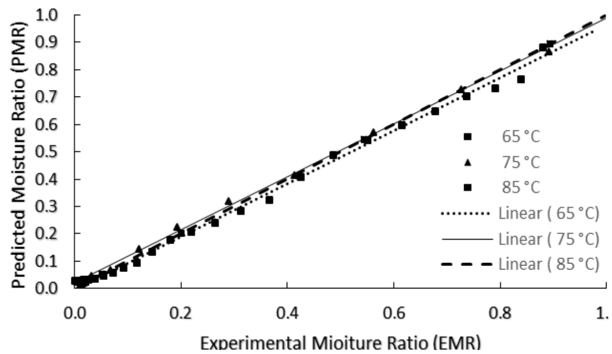

Figure 2. Experimental against Predicted Moisture Ratio at Different Temperatures

Table 6. Relations Between Predicted and Experimental Moisture Ratios at Different Temperatures

Temperature	Equation	R^2
65 °C (338K)	PMR = 0.9703EMR - 0.0060	0.99
75 °C (348K)	PMR = 0.9702EMP + 0.0194	1.00
85 °C (358K)	PMR = EMR	1.00

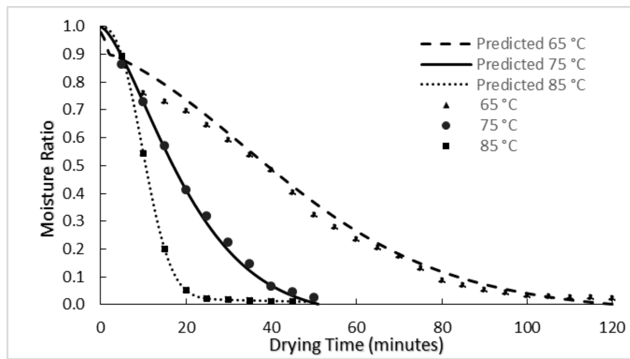

Figure 3. Variation of Experimental and predicted moisture ratio with drying time at different temperatures

ranging from 65°C to 85°C, the total drying times taken to reach a moisture ratio of about 0.1 is 20-80 minutes respectively. These drying times are shorter than the 4 - 8 hours experienced using the Excalibur Dehydrator, a commercial dryer designed by Discount Juicers (1998).

3.4 Estimating the Effective Moisture Diffusivity

Plots of experimental –ln(MR) against drying time (t), is shown in Figure 4, including the linear relationships between –ln(MR) and drying time for the different drying temperatures. The effective moisture diffusivity, D_{eff}, was obtained from the slope, k_d, at the different temperatures, according to Equation. 4.

The effective moisture diffusivity values for the 3.0 mm cucumber slices at 65°C, 75°C, and 85°C are 1.94 x 10^{-9} m^2/s, 2.41 x 10^{-9} m^2/s, and 2.54 x 10^{-9} m^2/s respectively. Clearly, the effective moisture diffusivity increases with increase in the water temperature in the Refractance Window^{TM} dryer.

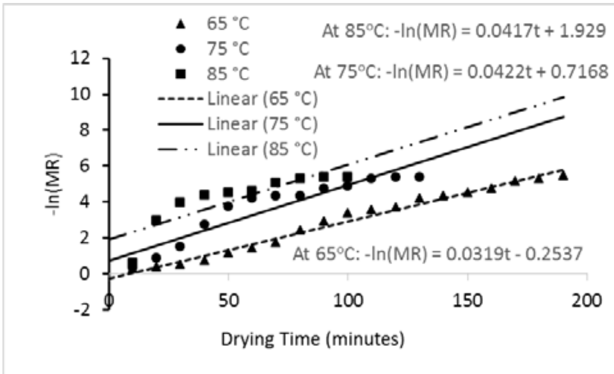

Figure 4. Relationship between Moisture ratio and Drying time at different temperatures

For comparing the results obtained, no documentation was found in the literature that considered the effective moisture diffusivity of cucumbers in a Refractance Window^{TM} dryer. However, the values of effective moisture diffusivities obtained in this study, lie within the general range of 4.00 x 10^{-13} to 6.10 x 10^{-7} m^2/s for fruits (Panagiotou *et al.,* 2004).

3.5 Estimating the Activation Energy

The activation energy E_a, is estimated by performing a linear regression analysis using the natural log of effective moisture diffusivity and the inverse of the temperature values at which they were determined. According to Equation 5, from the slope, kr, of the linear relationship, the activation energy, E_a, was obtained. For the temperature range 65-85^oC, the activation energy was estimated to be 13.55 kJ/mol with D_0, the pre-exponential factor equal to 15.21 m^2/s.

4. Conclusions

Cucumber (*Cucumis sativus*) fruit slices 3.0 mm thick, with an initial moisture content of 22.20 g-water/g-solid, were dehydrated to a moisture ratio of about 0.1 using a Refractance Window^{TM} (RW) dryer in which the flume water temperature varied between 65^oC and 85^oC; the conclusions are as follows. The drying rate of cucumber slices increased with increasing water temperature in the RW dryer. For the process conditions studied, cucumber fruit slices, 3 mm thick, dehydrated to a moisture ratio of about 0.1 within 80 minutes.

The effective moisture diffusivity increased in value with increase in the water temperature in the dryer. For the 3.0 mm thick cucumber slices at 65 ^oC (338K), 75 ^oC (348K) and 85 ^oC (358K), the effective moisture diffusivity was determined to be 1.94 x 10^{-9} m^2/s, 2.41 x 10^{-9} m^2/s, and 2.54 x 10^{-9} m^2/s respectively. This moisture diffusivity values are within the general range of 4.00 x 10^{-13} to 6.10 x 10^{-7} m^2/s for agricultural and food materials (Panagiotou *et al.,* 2004). Over the temperature range studied the activation energy was determined to be 13.55 kJ/mol.

In this study, the effective moisture diffusivity and activation energy of the cucumber fruit have been estimated using the Refractance Window^{TM} drying technique. These parameters are essential in the design, analysis, optimisation, and operations of Refractance Window^{TM} dryers.

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