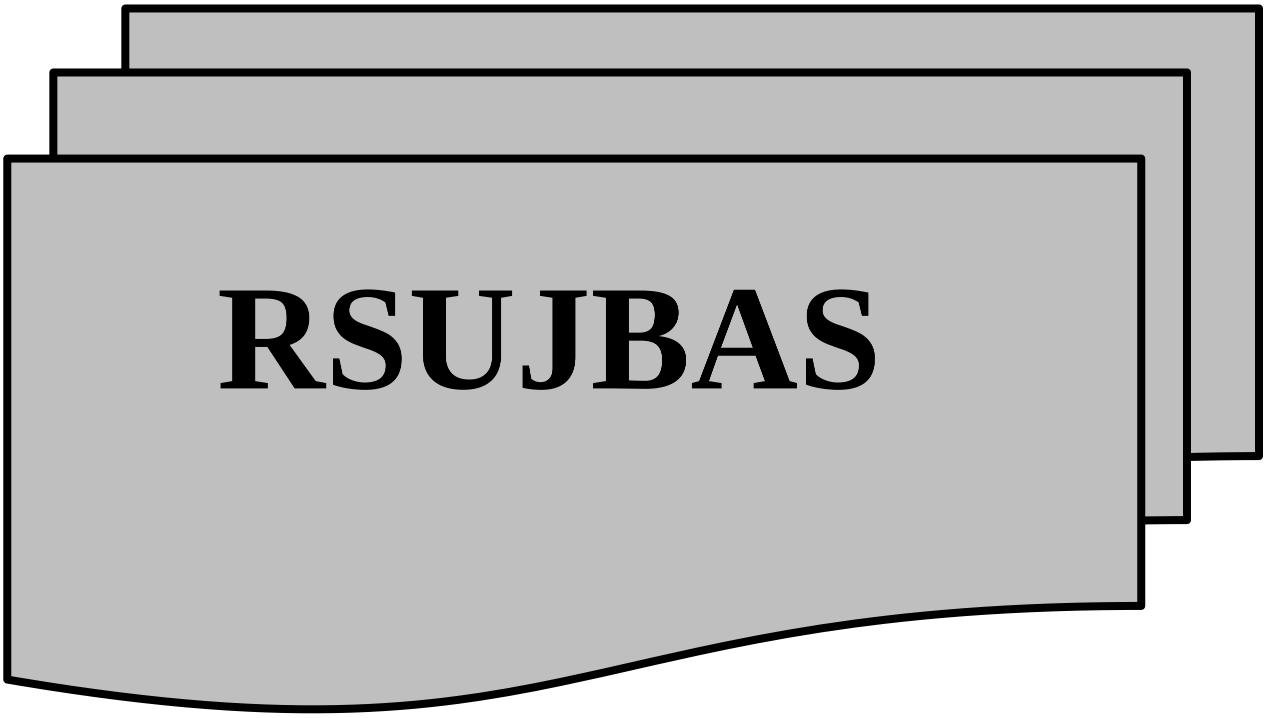
RSU JOURNAL OF BIOLOGY

AND

APPLIED SCIENCES

ISSN: 2811 – 1451



ABOUT US

Rivers State University Journal of Biology and Applied Science (RSUJBAS) publications is a quarterly, open access, international journal for all academic research in science discipline. Microbiology, botany, zoology, environmental biology, chemistry, physics, mathematics, computer science, biochemistry medical laboratory sciences and other applied science related areas. RSUJBAS is a platform set for elites to influence, contribute and communicate to the global environment through their various academic researches. We synergistically engage our noble effort to contribute to the knowledge development, discoveries and innovations in all fields of study. In RSUJBAS we publish research papers on current academic issues with standard scientific reviews. RSUJBAS publishes original research articles, review articles, case studies, short communications, survey report, comparative studies and many more.

Aims and Scope

Rivers state University Journal of Biology and Applied Sciences aims to publish high quality papers that communicate fundamentals and contemporary discoveries both theoretical and practical. Most importantly RSUJBAS seeks to establish a platform for communicating emerging trends in various discipline such as Microbiology, Botany, Zoology, Environmental Biology, Chemistry, physics, Mathematics, Computer Sciences, Biochemistry, Medical Laboratory, Sciences, and other applied sciences related areas.

Description:

- Area of concentration: All science academic disciplines
- Frequency of publishing: Quarterly
- Mode of publishing: both online and print publication
- Language of publication: English
- Double blinded Review Process
- Zero Level Plagiarism Tolerance

Why Publish with us

Low Article Processing Charge (ACP) to promote the research work
Easy and Rapid review process
Instant publication upon acceptance
Dedicated editorial and review team for fast review process
RSUJBAS provides hard copies of publication every quarterly

EDITORIAL BOARD

All Correspondence to
Prof Sam Wenedu (Editor -in -Chief)
Department of Microbiology, Rivers State University
edictor.ibasya@yoo.com

Or

OLUCHI DICKSON
Publication Manager
dicksonoluchi87@gmail.com

CONSULTING EDITORS

GUIDELINE FOR MANUSCRIPTS

Manuscripts should be typewritten on an A4sheet having B1.5=line spacing throughout the text. The margins should be 2B54cm (1 inch) in all sides and page number should be consecutively on the bottom of the page. The manuscript should be written in Times New Romans using ‘12’ font size.

For original research paper, the manuscript should be arranged in the following order: Tittle page, Abstract, Keywords Introduction, Materials and Methods Results, Discussion, Acknowledgement, References, Tables with legends and supplementary materials

The tittle page should contain the title, the name(s) of the author(s), the name(s) and address (es) of the instruction(s) where the work was carried out, including a valid e-mail address from the corresponding author along with telephone numbers. The title of the manuscript should be specific and concise but sufficiently informative.

The Abstract should not exceed 250 words and it should contain brief summary of the findings including brief introduction, methodology, results, and conclusions,

The keywords should have a minimum of five and maximum of seven words.

The introduction should provide a clear statement of the problem and indicates aim of the study citing relevant literature to support background statements.

The Materials and Method should include the methods and methodology of the research.

The results should be presented in the form of tables of figures. It should be presented with clarity and precision. Statements used to present results should be written in the past tense. Detailed interpretation of data should not be included in the results but should be put into the Discussion section.

The Discussion should interpret the results clearly and concisely, and should integrate the research findings of this and past studies on the topic. Highlight the significant/unique findings of the research under conclusion.

The acknowledgment of people, grants or funds should be brief.

TABLE OF CONTENTS

THIN LAYER DRYING KINETICS OF GINGER (*ZINGIBEROFFICINALE ROSCOE*)

Ifiemi Tulagha
*Department of Agricultural and Environmental Engineering,
Faculty of Engineering, PMB 071,
Niger Delta University Wilberforce Island Amassoma,
Bayelsa State, Nigeria
E-mail: ayibanoa4christ@yahoo.com, +2348139023350

Egbe Ebiyeritei Wisdom
*Department of Agricultural and Environmental Engineering,
Faculty of Engineering, PMB 071,
Niger Delta University Wilberforce Island Amassoma,
Bayelsa State, Nigeria

ABSTRACT

In this study, the optimum model for forecasting how quickly slices of ginger (Zingiber officinale roscoe) will dry was determined. In a convection-desiccant dryer, ginger slices were air dried in a single layer with a thickness of 4mm at various temperatures after conditioning them to eliminate moisture. Three distinct models were used to the experimental data in order to estimate and evaluate the findings of the best drying model. The reduced chi square, root mean square error (RMSE), and coefficient of determination (R^2) were used to assess the goodness of fit.

Key words: *ginger, drying, kinetics, thin layer, activation energy, moisture ratio.*

INTRODUCTION.

According to Onu et al. (2014) and Bijaya (2018) ginger is a Zingiberaceae family member that has been used for health purposes for about 10years. Its origins may be found in South-East Asia specifically in India and China and it was then brought to Africa and the Caribbean. These days, ginger is grown all across the humid tropics (Meadows, 1998). According to Onu et al. (2014) ginger is a monocotyledonous perennial herb with strong extensively branched edible underground rhizomes (horizontal stem) that grow close to the soil surface. These rhizomes give rise to the leafy shoots that make up the plant aerial portion.

Researchers have made a number of attempts to produce scientific evidence supporting the industrial processing and storage of food products. According to Crawford and Odle (2005) and Srinivasan (2017) ginger is one of the plants that has gained widespread popularity around the world for its use as a spice to flavor food and as a medicinal plant. As a result, it is often added to snacks, beverages, and drinks to improve digestion, act as an anti-inflammatory and provide other health benefits. According to Jelled et al. (2015) the presence of gingerols, volatile oils, shogaols, and strong antioxidant chemicals in ginger rhizomes is what gives the plant its health advantages.

Slices of dried ginger were examined by Loha et al. (2012) to determine how well they dried in a forced air convective cabinet dryer and the model developed by Midilli et al. (2012) that most accurately captured how thinly sliced ginger was dried. Afolabi et al. (2014) examined the impacts of thin layer drying behavior utilizing heated at oven temperature between 40 and 70C with air speed at 1.5m/s for ginger root slices that were 5-15mm with a different of 5mm thick. According to the results, drying times were declined when both sliced thickness and the drying air temperature were raises. These models make it possible to forecast the ideal conditions for drying such food goods.

The kind, variety, agronomic circumstances, curing procedures, drying procedures, and storage conditions all affect the nutritional composition of ginger. Generally speaking, it has the following nutritional analysis: protein (2.3%), fat (0.9%), carbs (12.3%), minerals (1.2%), fiber (2.4%), and moisture (80,9%) are the other components. Along with vitamins like thiamine, riboflavin, niacin, and vitamin C, it also contains minerals like phosphorus, calcium, and iron (Bijaya, 2018).

Ginger rhizomes can either be collected by hand or using a mechanized digger depending on how they will be used, ginger rhizomes are picked at various periods for example, for fresh consumption: When the leaves begin to turn yellow which occurs after 5 months then ginger can be stored for 5-7 months while for 8–9 months for dried ginger preparation and oil production (FAO)

Fresh ginger contains a lot of moisture (80–95%) promotes microbial degradation and causes significant losses after harvest (Osae *et al.*, 2019). Drying is a popular technique for preserving food after harvest. In essence, drying is a procedure that improves both heat and mass transmission (Dincer, 1998) and it remains a very effective method of food preservation, by reducing microbiological, enzymatic activities brought on by a significant amount of moisture present, extending the biomaterial self-life, it protects the safety of food goods during the storage term, it reduces transportation and packing expenses, enables year-round product availability, improves product aesthetics, and maintains the nutritional value and flavor of the product (Bijaya, 2018; Deng *et al.*, 2018). Ginger is dried in two stages: first the rhizomes are peeled to remove the outer layer then they are mechanically or sun-dried to a safe moisture content (Balakrishnan, 2005). The majority of developing nations sundry the scraped ginger, whereas those with bad seasonal conditions use more advanced drying techniques.

This work assessed the drying properties of ginger using thin layers in order to define its drying kinetics. The experimental output data was then fitted into various thin layer drying models.

2.0 MATERIALS AND METHODS

2.1. Sample preparation and Experimental procedure.

For this investigation, ginger tubers were purchased from a neighbourhood at Tombia market and with the help of a slicer similar to a Mandolin the ginger tubers were cleaned, peeled and sliced into 4 mm-thick pieces. After that the slices are dried on the drier at 60, 70, 80, 90, and 100 degrees Celsius in the convection oven. In addition to recording, the 4g weight of the ginger root slices were measured using electronic weighing balance and their thickness were measured using a digital Vernier caliper. Zibokere and Egbe (2020) also kept track of how much weight was lost during the drying experiment due to dehydration. When no noticeable changes are seen after 5 minutes the drying process is terminated (Mohsenin,1986).

2.2 Analysis of the Drying Curve

The moisture ratio formula was used for the sliced ginger.

$$\mathrm{MR} = \frac{M_t - M_e}{M_0 - M_e} \qquad 1$$

Where M= Moisture content at time.

M_t is the moisture content at t.

M_0 is the initial content moisture % .

Subsequently, plot of MR versus time was done to obtain the curve.

2.3 Selection of the Appropriate Model

Three models with various moisture ratio equations were fitted with the experimental drying data. (Table1)

Table 1. Model fitted to the drying curves

Model	Equation
Lewis model	MR_{pred} =exp(-kt)
Handerson model	MR_{pred} = aexp(-kt)
Page Model	MR_{pred} =exp(-kt^n)

To determine the suitability of the drying model, the acquired data were assessed using three statistical metrics: the R^2, RMSE, and X^2. The model with the highest R^2, the lowest RMSE, and the lowest X^2 values is the one that is most appropriate. These three parameters can be found using equations 2, 3, and 4.

$$R^2 = \frac{\left[\sum_{i=1}^{N}(MR_{exp,j}-MR_{esp})(MR_{pre,j}-MR_{pre})\right]^2}{\sum_{i=1}^{N}(MR_{exp,j}-MR_{exp})^2\sum_{i=1}^{N}(MR_{pre,i}-MR_{pre})^2} \qquad 2$$

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(MR_{exp,i}-MR_{pre,i})^2} \qquad 3$$

$$X^2 = \frac{\sum_{i=1}^{N}(MR_{exp,i}-MR_{pre,i})^2}{N-z} \qquad 4$$

2.4 Estimation of effective moisture diffusivity.

The following equation, known as Ficks law of equations, was used to compute the effective diffusivity value, abbreviated as Deff (Egbe and Ebienfa, 2022)

$$MR = \frac{8}{\pi}\sum_{n=0}^{\infty}\frac{1}{2n+1}esp\left[\frac{(2n+1)\pi^2}{4L^2}\right] \qquad 5$$

$$MR = \frac{8}{\pi^2}esp\left[\frac{\pi^2 D_{t^2}}{4l^2}\right] \qquad 6$$

Then equation (6) can be linearized into:

$$\text{In } MR = \text{In}\,\frac{8}{\pi^2} - \frac{\pi^2 D_{eff^1}}{4l^2} \qquad 7$$

2.5. Activation Energy

The Arrhenius type equation which was used to arrive at this conclusion (Egbe *et al.,* 2022 Akgun and Doymaz, 2005; Sanjuan et al., 2003), explains the link between the drying temperature and the diffusion coefficient as follows.

$$Deff = Do\text{exp}(-\frac{E_a}{R*T}) \quad 8$$

$$\text{In } Deff = \text{In}Do - \frac{E_a}{R}\frac{1}{T} \quad 9$$

Activation energy can be calculated to be

$$\text{Y} = \frac{E_a}{R} \quad 10$$

Where Y is the slope of the D_{eff} plot of 1/T and R is the gas constant (J $mol^{-1}K^{-1}$).

3.0 Results and Discussions

3.1 Evaluation of the Drying Curve

The sample moisture ratio dropped as drying time increased as shown in Figures 1 and 2 which shows the drying values obtained from the sample. The drying curve approaches the drying time tangentially, although it does so slowly because to the high systemic water content in the ginger. The slow-moving curve pattern also demonstrated that there was no case-hardening in the high-temperature zones during the dying phase. All of the MR are calculated on a dry basis (db). The graphs in the Figure 1 appear to have adopted the general pattern of drying curves that has been reported for a variety of biomaterials. The curves had a steeper slope at first indicating greater and faster evaporation of moisture during drying. This may be because moisture moved to the surface for evaporation and evacuation more quickly in the samples, which led to increased water activity in the samples and reducing the drying time. However, even with increasing temperatures the drying process got slower (the curves flattened) as less and less water became available for evaporation at the surface of the samples. This is typical of biomaterials with a high component content, even with an increase in drying temperature, moisture coupled with fats/oils and protein considerably reduces water activity (Zibokere and

Egbe, 2019; Jain and Pathare, 2007). The condition is also consistent with studies on thin layer drying operations on fresh water clams (Burubai, 2015), fresh tilapia fish (Zhiqiang *et al.*, 2013), salted catfish fillets (Sankat and Mujalfar, 2006), and fresh fish (Sankat and Mujalfar, 2006). (Kilic, 2009).

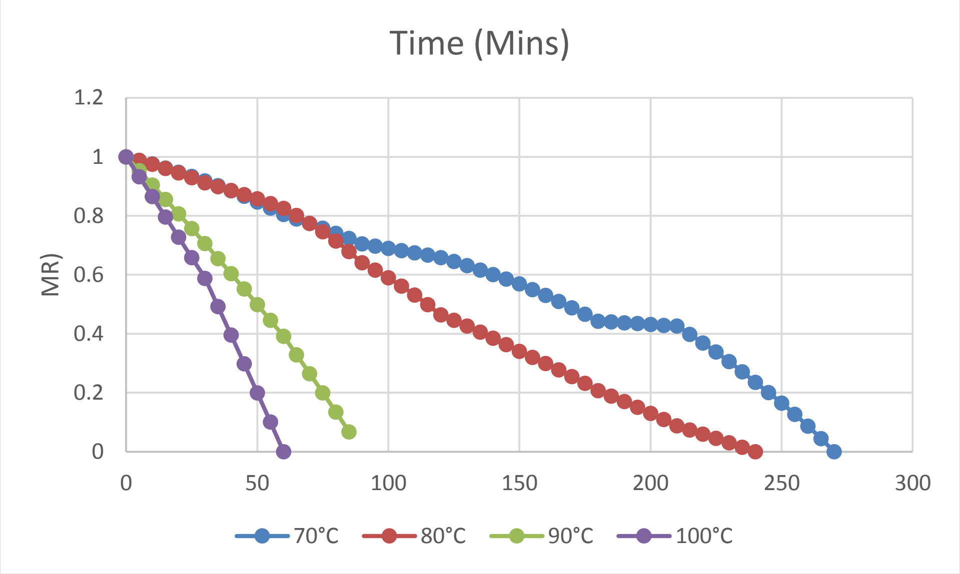


Fig. 1: Drying curve at different temperature*)*

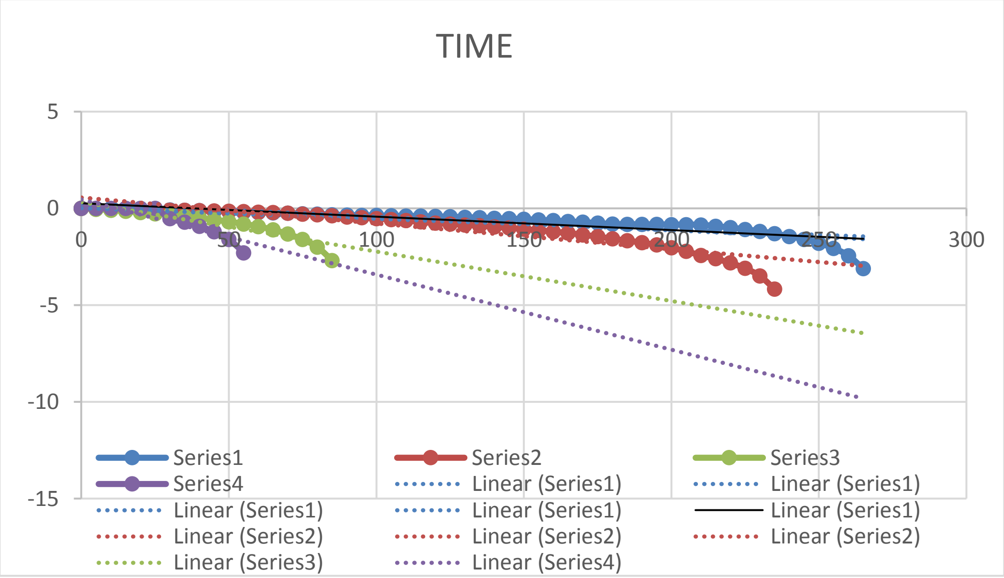


Fig. 2. A plot of logarithmic moisture ratio [ln(MR)] as a function of drying time

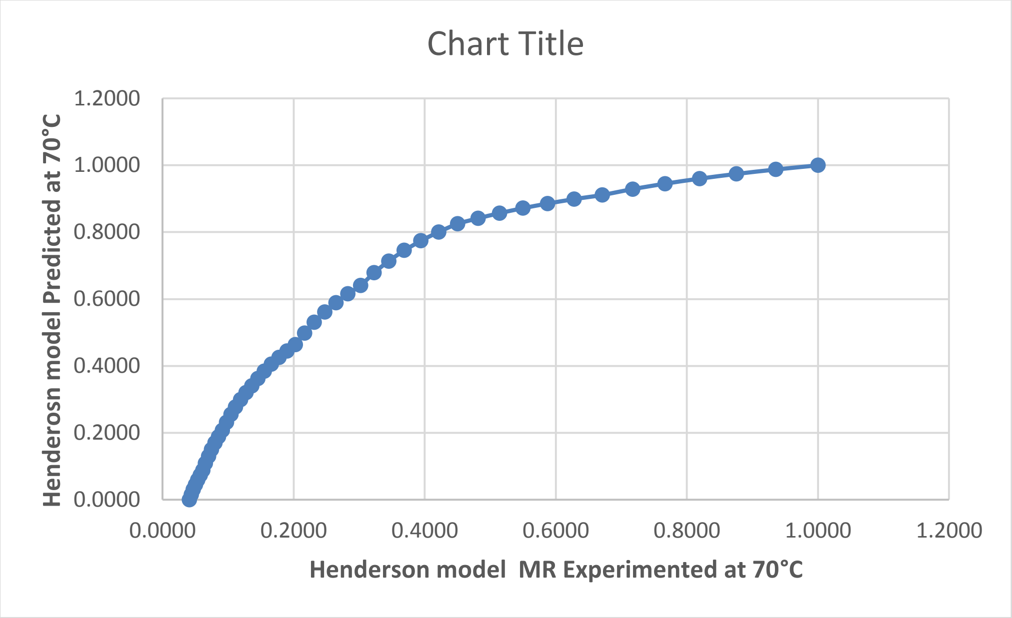


Figure 3. Compared Predicted MR with Experimented MR by Henderson model

3.2. Selection of the Appropriate Model

The Page model, Henderson-Pabis model and Lewis model were each used separately to calculate the experimental drying values. To determine which model would portray the drying the ginger the best, a fitting was conducted. The data were fitted to Fick's second law of diffusion equation, and the constant 'k' as well as the coefficients 'a' and 'n' were determined using a non-linear least squares method (SPSS 1996). The R^2, RMSE, and X^2 obtained from the plot of the experimental moisture ratio against the projected moisture ratio were then validated by performing the calculations described in tables 2 for the R^2, RMSE, and X^2. For the purpose of representing the specimen drying feature, the model with the lowest RMSE, X^2 and maximum R^2 was determined to be the most suitable. Out of the three models employed in this study, Henderson and the Page model were found to have the best fit to the drying characteristic of ginger.

Table 2: Values of Statistical Analysis Equation of Drying Models

LEWIS MODEL						
Temp. °C	R^2	X^2	RMSE	K	A	N
60°C	0.6577	$6.33951x10^{3}$	0.078893899	0.0069	-	-
70°C	0.9618	$7.94934x10^{4}$	0.027905395	-0.00133		
80°C	0.9726	$8.67504x10^{4}$	0.030275125	-0.0255		
90°C	0.9826	$9.67504x10^{4}$	0.030275125	-0.0255	-	-
100°C	0 9516	$4.03085x10^{3}$	0.060998225	-0 0388	-	-
HANDERSON MODEL						
60°C	0.9999	$7.19x10^{7}$	0.000832437	0.0069	1.297319	-
70°C	0.9992	$1.68652x10^{5}$	0.004022038	-0.00133	1.732733	-
80°C	0.9998	$1.61669x10^{5}$	0.004683804	-0.0255	1.569437	
90°C	0.9997	$1.51669x10^{5}$	0.003683804	-0.0255	1.369437	-
100°C	0.9998	$2.00096x10^{5}$	0.00411755	-0 0388	1.585183	-
PAGE MODEL						
60°C	0.9512	$1.72734x10^{2}$	0.129016509	1.2612		0.001201
70°C	0.9718	$3.75328x10^{3}$	0.060000665	2.7829		0.000865
80°C	0.9826	$3.82415x10^{3}$	0.073710023	1.4486		0.004141
90°C	0.9926	$3.22415x10^{3}$	0.083710023	1.348		0.004141
100°C	0 9916	$1.89605x10^{2}$	0.126663067	2.456		0.000165

3.3. Effective Diffusivity (D_e) and Activation Energy E_a

The graphs between the natural logarithms of the moisture ratio (ln MR) and drying time were used to illustrate the effects of temperature and airflow on the effective diffusion coefficient of ginger in Figure 2. As the drying temperature rises, it can be seen that Deff values rise as well. Higher heating energy would increase the activity of water molecules, resulting in higher moisture diffusivity when the items were dried at higher temperatures (Mghazli *et al.*, 2017). The De values ranged from 6.42x10-8-m^2/s to 4.085x10-6m^2/s. This is comparable to what has been observed in the case of palm weevil larvae (Zibokere and Egbe, 2019). Ea and Ln Deff versus 1/T were determined using equations 9 and 10 and 20.40 kJ/mol was the activation energy value.

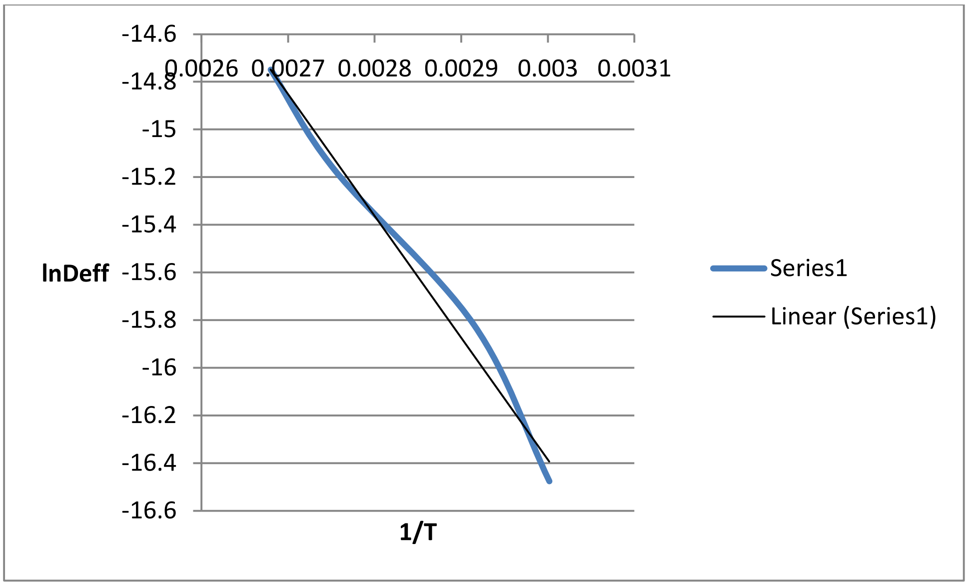


Figure 4. Estimation of Activation Energy

4. Conclusion

When the drying kinetics of ginger was examined, it became clear like other agricultural materials, the drying process belongs to the falling rate period. The Henderson model was were statistically analysed. 6.42x10-8-m^2/s to 4.085x10-6m^2/s was calculated as the Deff with respect to the temperatures studied. Amongst the three thin layer models examined the Henderson model best predicted the drying kinetics of ginger. The associated activation energy measurement yielded a value of 20.40 kJ/mol.

REFERENCES

Afolabi, T. J., Tunde-Akintunde, T. Y. and Oyelade, O. J., (2014), Influence of Drying Conditions on the Effective Moisture Diffusivity and Energy Requirements of Ginger Slices, Journal of Food Research, 3(5), p103.

Akgun N.A., Doymaz I. 2005. Modeling of olive cake thin-layer drying process. *J. Food Eng.*;68:455–461

ASAE (2000). Standard, publication of the American Society of Agricultural and Bioresources Engineering (S368 41 2000).

Balakrishnan, K.V. (2005). Postharvest and processing of Ginger: Ginger: The genus zingiber. Medicinal Atomic plants-industrial profiles Vol.41:375-395. CRC Press, Florida.

Bijaya B. Bag (2018). Ginger processing in india (Zingiberofficinale): A Review. Int.J.curr.Microbiol.App.Sci. 7(04):1639-1651. doi: https//doi.org/1.20546/ijcmas.2018.704.185

Burubai, W. (2015). Thin layer drying kinetics of fresh water clam (Tridacna maxima). *Umudike Journal of Engineering and Technology* 1(1): 79 – 90.

Crowford,s; and T.G. Odle (2005).Thyme. Int.J.L.Longe,ed; The gate encyclopedia of Alternative Medicine. Farmington Hills,Mich:Thomson/gale. ISBN 0787693960

Deng L.Z.,Yang, X.,H. Mujumdar, A.Zhao, J.H.,Wang, D. Zhang, Q.,…Xiao, H.W.(2018).Red pepper(capsicum annuml) Drying: Effect of different drying methods on drying kinetics, physiochemical properties, antioxidant capacity, and microstructure. Drying Technology, 36(8), 893-907.

Dincer, I. (1998). Moisture transfer analysis during drying of slab woods. Heat and mass transfer 34(4):317-320.Distributors, New Delhi.

Egbe E.W and Ebienfa PDI. (2022). Mathematical Modelling and the Determinationof Activation Energy and Moisture Diffusivity Effectiveness of Glass Shrimps (Palaemonetes paludosus). *RSU Journal of Biology and Applied Sciences (RSUJBAS)* – May, Volume 2 Number 1

Egbe E.W, Jonathan B.J, Ebienfa P.D.I and Abu H.C (2022). Modelling the Drying Behaviour of Garlic (*Allium sativum*). *International Journal of Current Research and Applied Studies* Vol 1 Issue 3 July-August 2022. Page 14-25. available at https://ijcras.com

FAO, 2006. Major food and agricultural commodities and producers. Databases FAOSTAT, online at: http://www.fao.org/es/ess/top/comm

Jain, D; and Pathare, P.B; 2007, study the drying kinetics of open sun drying of fish, *Journal of food Engineering*, 78(4), pp. 1315-1319.

Jelled A., Angela Femandes, Lillian Barros, Hassibachahdoura, LoftiAchour Isabel CFR, (2015). chemical and antioxidant parameters of dried ginger rhizomes. Industrial crops and products 77, 30-35.

Kilic, A. 2009. Low temperature and high velocity (LTHN) application in drying: characteristic and effects on fish quality. *Journal Food Engineering* 91, 173 – 182

Loha, C., Das, R., Choudhury, B., and Chatterjee, P. K., (2012). Evaluation of Air-Drying Characteristics of Sliced Ginger (Zingiber officinale) in a Forced Convective Cabinet Dryer and Thermal Conductivity Measurement. *J Food Process Technol*, 3(130), 2.

Meadow, A.B,(1998).Ginger processing for food and industry. Proceedings of the first ginger National workshop, Umudike, pp 34-42

Midilli, A., Kucuk, H., and Yapar, Z., (2012), A New Model for Single-Layer Drying, *Drying Technol*., 20(7), 1503-1513.

modelling on hot air drying of thin layer apple pomace. *Journal of Food Engineering* 40, 39 - 46.

Mghazli S, M. Ouhammou, N. Hidar. L. Lahnine, A. Idlimam, M. Mahrouz. (2017). Renewable Energy. 105 ISSN: 0960-1481

Mohsenin, (1986).1st Edition "Physical properties of plant and animal materials". Vol. 1: Physical characteristics and mechanical properties 25, 123-44. Gorgon Beach Science Publishers, USA.

Onu, O. O, K. J. Simonyan, M.C. Ndukwu (2014).A review of postharvest and processing technologies of ginger (Zingiberofficinale) in Nigeria. Conference proceedings 2014 international conference and 35th annual General meeting of the Nigerian institute of Agricultural Engineering (NIAE) at Akure vol. 35.

Osae R., Essilfie G, Alolga R.N, Bonah E., Ma H, Zhou C. Drying of ginger slices- Evaluation of quality attributes, energy consumption, and kinetic study. *J of food process Eng*. 2019, 43: e13348.

Sankat C. K and Mujaffar S. (2006). Modelling the drying behaviour of salted catfish fillets. *15th International Drying Symposium* (IDS 2006), Budapest Hungary, 20 – 23 August

Sanjuan N., Lozano M., Garcia-Pascal P., Mulet A. Dehydration kinetics of red pepper (Capsicum annuum L. var. Jaranda) *J. Sci. Food Agric.* 2003;83:697–701.

SPSS Inc.1996. SPSS for Windows, Release 7.5.1.

Srinivasan, K. (2017). Ginger rhizomes (Zingiberofficinale), Aspiece with multiple health beneficial potentials. P*harma Nutrition* 5(1), 18-28.

Zhiqiang, D; Wang, X; Li, M and X. Jiang. 2013. Mathematical modelling of hot air drying of thin layer fresh tilapia fillets. Pol. Journal of Food Nutrition Science 63(1), 25 – 34.

Zibokere, D. S and Egbe, E. W. (2019). Thin-layer Drying Kinetics of Palm Weevil (Rhynchophorus ferruguneus) Larvae. *Annals of Applied Science* 5(2): 40 – 46.

Zibokere, D.S., and Egbe, E.W (2020). Estimating the drying kinetics of spiced Okpokuru (Orycles rhinoceros) with the use of some of the thin layer models. Research Journal of Engineering and Environmental Sciences, 5(2), 563-574.