# Convective Hot Air Drying of Different Varieties of Blanched Sweet Potato Slices

M. O. Oke, T. S. Workneh

***Abstract***—Drying behavior of blanched sweet potato in a cabinet dryer using different five air temperatures (40-80°C) and ten sweet potato varieties sliced to 5mm thickness were investigated. The drying data were fitted to eight models. The Modified Henderson and Pabis model gave the best fit to the experimental moisture ratio data obtained during the drying of all the varieties while Newton (Lewis) and Wang and Singh models gave the least fit. The values of Deff obtained for Bophelo variety (1.27 x 10-9 to 1.77 x 10-9 m2/s) was the least while that of S191 (1.93 x 10-9 to 2.47 x 10-9 m2/s) was the highest which indicates that moisture diffusivity in sweet potato is affected by the genetic factor. Activation energy values ranged from 0.27-6.54 kJ/mol. The lower activation energy indicates that drying of sweet potato slices requires less energy and is hence a cost and energy saving method. The drying behavior of blanched sweet potato was investigated in a cabinet dryer. Drying time decreased considerably with increase in hot air temperature. Out of the eight models fitted, the Modified Henderson and Pabis model gave the best fit to the experimental moisture ratio data on all the varieties while Newton, Wang and Singh models gave the least. The lower activation energy (0.27 - 6.54 kJ/mol) obtained indicates that drying of sweet potato slices requires less energy and is hence a cost and energy saving method.

***Keywords*—**Sweet Potato Slice, Drying Models, Moisture Ratio, Moisture Diffusivity, Activation Energy.

## I. Introduction

CARBOHYDRATE source in the diet of human being includes sweet potato (*Ipomoea batatas* L.) which has its root rich in potassium, β-carotene and fibre. It is therefore widely used in ready-to-eat foods including cake, biscuits, bread, juice and noodles' ingredient [1]. Sweet potato drying usually performed traditionally with the use of sun, which is a time consuming method (about 56 hrs) and produces an inferior quality product with high health risk due to high contamination [2]. The most employed way to reduce the drying time and obtain good quality product is the use of mechanical dryers. It also lowers the product mass and volume which improves the efficiency of storing, packaging and transportation [3].

Most food products are usually subjected to one form of pre-treatments or the other before drying. One of the pre-treatments is hot water blanching which inactivate enzymes that lead to some improvement of the final products [4]. Blanching also leads to structural softening and hence, facilitates moisture removal [5]. The most important aspect of drying technology is modelling of the drying processes and equipment [6]. The drying kinetics of food is a phenomenon that is complex and requires simple representations to predict the drying characteristics and behaviour, and for optimizing the drying parameters. Modelling principle is based on having a set of mathematical equations that can effectively characterise the system [7], [8].

Describing drying process, thin-layer drying models are the most common models used in all mathematical models in the literature. They have been used to estimate drying times of several products and to generalise drying curves. Generally, in the development of thin-layer drying models, the moisture content of the material at any time after it has been subjected to a constant relative humidity (RH) and temperature condition is measured and correlated to the drying parameters [9]. Some thin-layer equations available in the literature for describing drying characteristics of agricultural products have been used by [10] for apricot, [11] for pistachio, [12] for carrot, [13] for mint leaves, [14] for parsley leaves, [15], [16] for apple slices, [17] for date palm fruits, [18] for apples, [19] for tiger nut seeds and [20] for tomato slices.

There is little or no information about the modelling of the drying process for a forced convection of sweet potato slices of different varieties in the literature. Therefore, the main objectives of the present study were to investigate the thin-layer drying characteristics of blanched sweet potato slices under forced convection mode, fit the experimental data to drying models, determine the effective diffusivities within the temperature range and establish the activation energy.

## II. Materials and Methods

Fresh sweet potato used in this study was obtained from the Sweet potato Breeding and Technology Transfer field, Agricultural Research Council-Roodeplaat Vegetable and Ornamental Plant Institute, South Africa. The sample tubers were stored at $4^oC$ and 80-90% relative humidity until use [21]. The sample tubers were sorted, peeled using stainless steel knife, washed in clean water, cut into slices of thickness of 5.0 ± 0.2 mm. The sample slices were blanched in water bath at about $100^oC \pm 1^oC$ for 2 min and immediately cooled to $25^oC$ water bath immediately for 5 min [4]. The blanched slices were then placed between moistened towels before the start of drying run.

The convective hot air dryer (Gallenkamp SG94⁄ 04 ⁄ 609, Sanyo Gallenkamp Plc, Loughborough, UK) was run for about 30 min to obtain steady conditions before placing samples in the chamber. The drying was carried out at 40, 50 60, 70, and $80^oC$ air drying temperatures and 1.5 m $s^{-1}$ drying air velocity.

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The samples were placed on the drying tray in a thin-single-layer. The dimension of the samples (40 x 50 x 5 mm) was kept constant for all experimental runs. Changes in weight of slices were monitored at 5 min interval for the first forty five min, 15 min interval for another three hours and one hour interval for subsequent drying times until the samples reached the desired moisture content of < 10 %, wet basis [13], [22].

*A. Mathematical Modelling Formulation of Drying Curves*

The thin layer drying models in Table I were tested to select the best model for describing the curve equation of sweet potato slices during drying process. Nonlinear regression analysis was performed using SPSS (Statistical Package for Social Scientists, Chicago, IL, USA) 16.0 program to determine coefficient of determination ($R^2$) and model constants. The $R^2$ was the main criterion for selecting the best equation to describe the drying curve. In addition, the chi square ($\chi^2$) and the root mean square error (RMSE) analyses were used to determine the goodness of fit. The higher the values of $R^2$, the lower were the values of $\chi^2$ and RMSE, and hence the better goodness of fit [11], [19], [20], [23]-[25].

The criteria above can be calculated as follows:

$$\chi^2 = \frac{\sum_{i=1}^{N}\left(MR_{(\exp,i)} - MR_{(pred,i)}\right)^2}{N-z} \quad (1)$$

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}(MR_{pred,i} - MR_{\exp,i})^2\right]^{\frac{1}{2}} \quad (2)$$

TABLE I
THIN-LAYER DRYING MODELS

| Model name | Model equation | References |
|---|---|---|
| Newton (Lewis) | $MR = \exp(-kt)$ | [10], [19], [20], [24] |
| Henderson and Pabis | $MR = a\exp(-kt)$ | [19], [24] |
| Page | $MR = \exp(-kt^n)$ | [5], [12], [20], [23] |
| Logarithmic | $MR = a\exp(-kt) + b$ | [12], [20] |
| Wang and Singh | $MR = 1 + kt + ct^2$ | [16], [19], [20] |
| Parabolic | $MR = a + kt + ct^2$ | |
| Modified Henderson and Pabis | $MR = a\exp(-kt) + b\exp(-gt) + c\exp(-ht)$ | [26] |
| Midilli and Kucuk | $MR = a\exp(-ktn) + bt$ | [9] |

*a*, *b*, *c*, *n*, *g*, *h* are the drying coefficients and *k* is the drying constant ($min^{-1}$).

## III. Results and Discussion

*A. Dryind Curves*

The variations of drying curves for sweet potato slices as a function of variety during air-drying at different drying temperatures are shown in Figs. 1-5. Increase in drying air temperatures resulted in decrease in the drying times which means that the moisture ratio decreased continuously with drying time. Higher values of moisture ratios were observed in Bophelo variety which was followed by Mvuvhelo while the least moisture content was found in variety S191 slices dried under all the drying temperatures, except at 80$^o$C where the highest moisture ratio was found in Mvuvhelo followed by Bophelo variety sweet potato slices. The decrease in moisture ratio indicates that diffusion has governed the internal mass transfer. This observation is in line with the reports of [27] on onions; [28] on lettuce and cauliflower leaves [29] on figs.

The drying time varied between 15.75 and 19.75 hrs. With increasing input drying air temperature, more energy rate applied to the sweet potato slices and caused an increase in drying rate. Therefore, drying air temperature had an important effect on drying time (Fig. 6). Due to the quick removal of moisture at higher temperature (80$^o$C) considered in this study, the drying time was less. Similar observations have been reported for drying of garlic slices [30], egg plants [6], tigernut [19], red beet [31] and tomato slices [20].

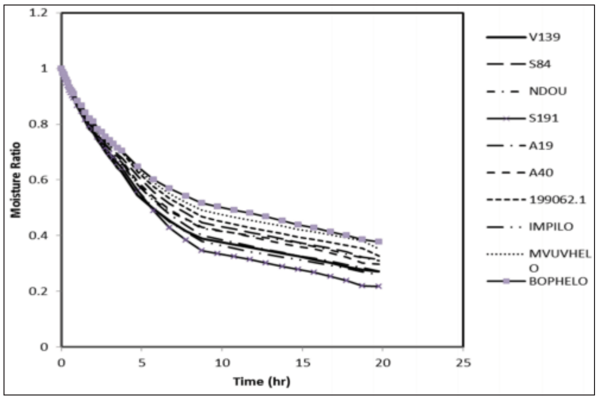


Fig. 1 Variation of drying curves for sweet potato slices as a function of variety during convective drying at 40$^o$C

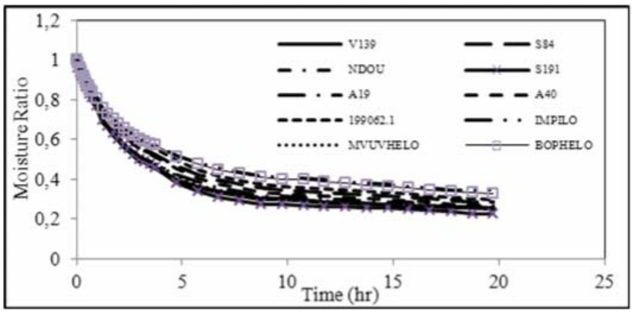


Fig. 2 Variation of drying curves for sweet potato slices as a function of variety during convective drying at 50$^o$C

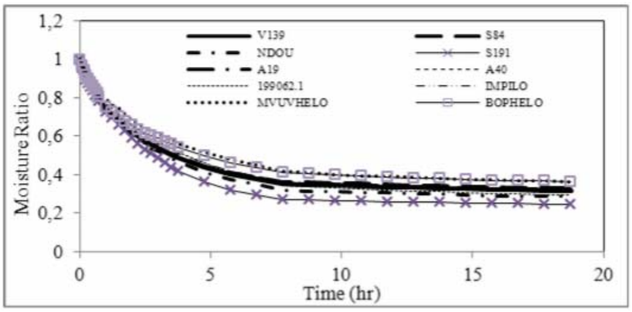


Fig. 3 Variation of drying curves for sweet potato slices as a function of variety during convective drying at 60$^o$C

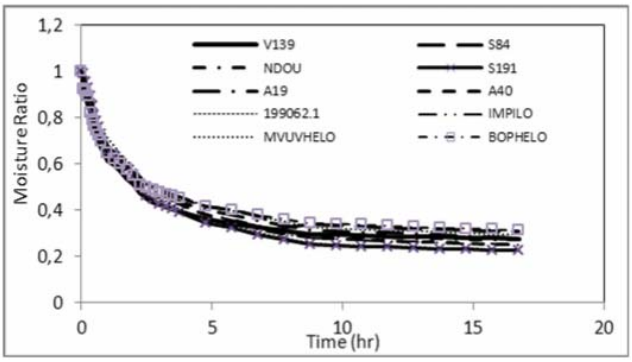


Fig. 4 Variation of drying curves for sweet potato slices as a function of variety during convective drying at $70^{o}C$

The sweet potato slices experienced both constant and falling drying rate period (Figs. 1-5). Similar findings were obtained by [32] who worked on the effects of far-infrared radiation on the freeze-drying of sweet potato. Consequently, the effect of hot air temperature in forced air ventilation drying has been reflected in drying rate. The rate of moisture removal from sweet potato slices at $80^{o}C$ drying temperature was higher and faster than the other investigated temperatures ($40\text{-}70^{o}C$). The drying process took place largely in the falling drying rate period which shows a quick removal of moisture from the sample's surface.

At the start of drying process, the drying rate was at its highest, but later decreased as the drying proceeded until the moisture content reached equilibrium at which no more moisture is removed. This is in agreements with the observations from researches carried out for water chestnut by [33], and radish slices by [34]. However, the drying air temperature increased the dried product freshness quality characteristics losses [10], [12], [30].

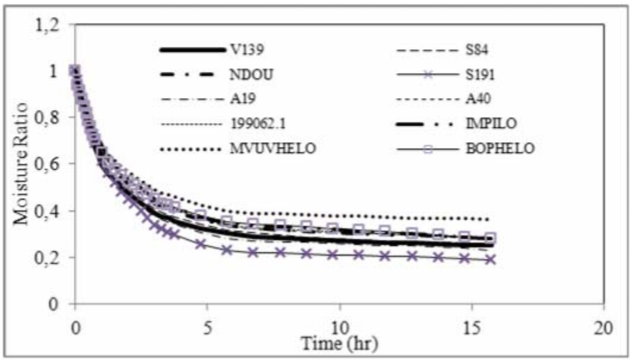


Fig. 5 Variation of drying curves for sweet potato slices as a function of variety during convective drying at $80^{o}C$

*B. Modelling of Drying Curves*

Drying data obtained were fitted into eight thin layer drying equation models (Table I). The statistical results obtained from the non-linear regression of the models for evaluating goodness of fit (coefficient of determination ($R^2$), the reduced chi-square ($\chi^2$), root mean square error (*RMSE*)) and the equation constants and coefficients for all the eight models at different drying temperatures were used to compare the models (as an example, see Tables II and III).

The best model to describe the drying characteristics of the sweet potato slices was selected on the basis of highest $R^2$ and lowest $\chi^2$ and RMSE values. In all, the $R^2$ values varied from 0.911 to 0.999 ($40^{o}C$); 0.731 to 1.000 ($50^{o}C$); 0.624 to 1.000 ($60^{o}C$); 0.360 to 0.999 ($70^{o}C$) and 0.367 to 0.999 ($80^{o}C$). The $\chi^2$ values varied from 6.02E-05 to 0.547167 ($40^{o}C$); 0.000149 to 0.436658 ($50^{o}C$); 0.00034 to 0.44595 ($60^{o}C$); 0.000366 to 0.329876 ($70^{o}C$) and 0.000516 to 0.373269 ($80^{o}C$). The RMSE values varied from 0.007654 to 0.72991 ($40^{o}C$); 0.012027 to 0.652048 ($50^{o}C$); 0.01817 to 0.658711 ($60^{o}C$); 0.018871 to 0.566741 ($70^{o}C$) and 0.022379 to 0.602166 ($80^{o}C$). The values of $R^2$, $\chi^2$ and RMSE for all the models varied from 0.360 to 1.000; 6.02E-05 to 0.547167 and from 0.007654 to 0.72991 respectively. Considering hot air ventilation drying of the sweet potato slices at the drying temperatures considered ($40\text{-}80^{o}C$), the overall values of $R^2$ [0.999 at $40^{o}C$ (S84, Bophelo, V139 samples), $70^{o}C$ (NDOU, 199062.1, V139 samples) and $80^{o}C$ (S191, A19, NDOU samples); 1.000 at 50 (S84, Impilo, V139, A19, 199062.1, Mvuvhelo samples) and $60^{o}C$ (S84, Bophelo, V139 samples) obtained from Modified Henderson and Pabis model is the highest compared to other models. Thus, Modified Henderson and Pabis model is best fitted to the experimental dimensionless moisture content data followed by the Midili and Kucuk and Logarithmic models.

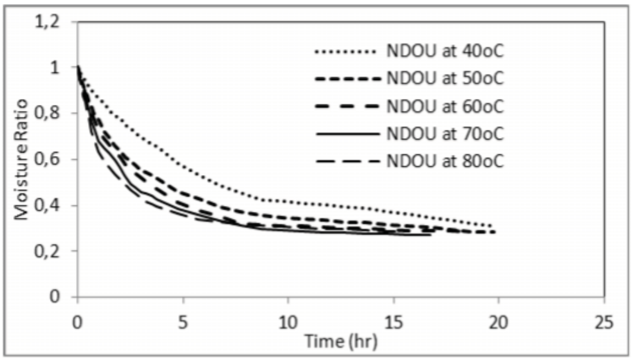


Fig. 6 Typical sample of the variation of moisture ratio of NDOU sweet potato slices as a function of drying temperature

However, considering the model that had the lowest $\chi^2$ and RMSE values, Midili and Kucuk model ($\chi^2$ = 6.02E-05 and RMSE = 0.007654 for Bophelo variety at $40^{o}C$; $\chi^2 = 0.000149$ and RMSE = 0.012027 for S84 variety at $50^{o}C$; $\chi^2 = 0.000339$ and RMSE = 0.01817 for A19 variety at $60^{o}C$; $\chi^2 = 0.000366$ and RMSE = 0.018871 for S191 variety at $70^{o}C$; $\chi^2 = 0.000516$ and RMSE = 0.022379 for NDOU variety at $80^{o}C$) best fitted to the dimensionless moisture content data followed by Modified Henderson and Pabis model ($\chi^2 = 0.000308$ and RMSE = 0.017319 for Bophelo variety at $40^{o}C$; $\chi^2 = 0.001189$ and RMSE = 0.034019 for S84 variety at $50^{o}C$; $\chi^2 = 0.001678$ and RMSE = 0.040404 for Impilo variety at $60^{o}C$; $\chi^2 = 0.00242$ and RMSE = 0.048538 for NDOU variety at $70^{o}C$; $\chi^2$

= 0.002559 and RMSE = 0.049856 for NDOU variety at 80°C). Based on these results, the Modified Henderson and Pabis model is selected as the suitable model to predict the hot air drying of sweet potato slices of all the varieties at different drying temperatures followed by Midili and Kucuk and Logarithmic models.

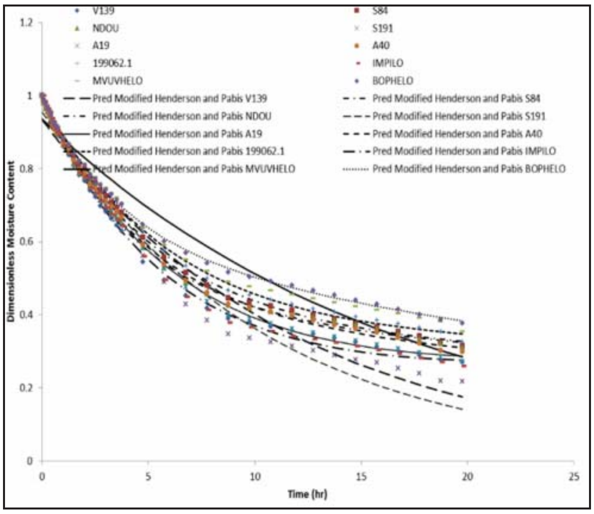


Fig. 7 Comparison between experimental and predicted moisture ratios using Modified Henderson and Pabis model for convective hot air drying of sweet potato slices as a function of drying time at 40°C

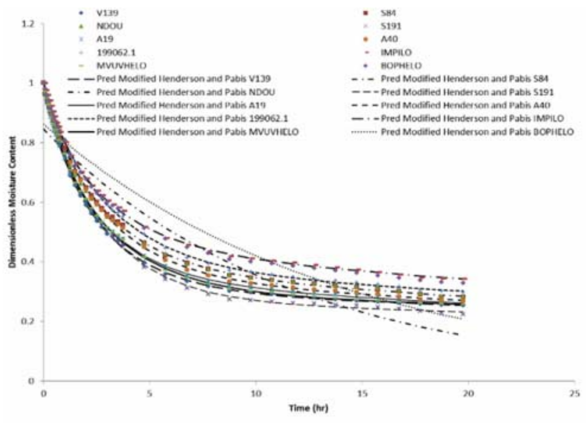


Fig. 8 Comparison between experimental and predicted moisture ratios using Modified Henderson and Pabis model for convective hot air drying of sweet potato slices as a function of drying time at 50 °C

The comparison between the experimental and predicted data using the Modified Henderson and Pabis model for hot air drying of all the sweet potato slices at different temperatures are indicated in Figs. 7-11. There is conformity between experimental and predicted moisture ratios in all the figures. This is due to the same path followed by the experimental and predicted values for the model. These show the suitability of the model in predicting the drying characteristics of sweet potato slices. The use of the Modified Henderson and Pabis model to predict the convective drying characteristics of sweet potato slices is similar to the observations for the drying characteristics of apple slices [15], [16]. There is also a good agreement between the variables which is in line with previous research findings by [30] for drying garlic slices, and by [12] for carrots drying.

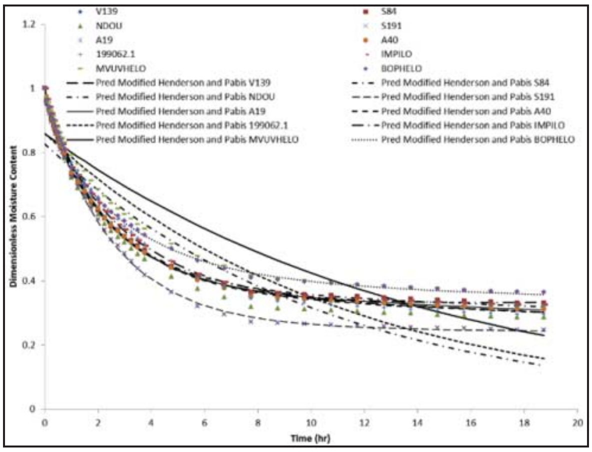


Fig. 9 Comparison between experimental and predicted moisture ratios using Modified Henderson and Pabis model for convective hot air drying of sweet potato slices as a function of drying time at 60°C

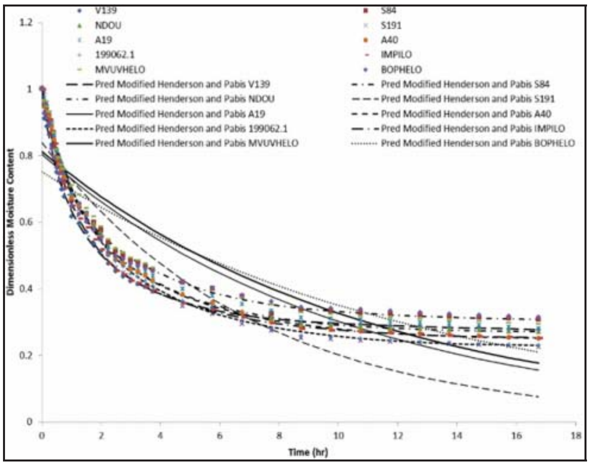


Fig. 10 Comparison between experimental and predicted moisture ratios using Modified Henderson and Pabis model for convective hot air drying of sweet potato slices as a function of drying time at 70°C

TABLE II
COEFFICIENTS AND CONSTANTS FOR THE SIX MODELS USED FOR DRYING OF VARIETY V139 AT THE DIFFERENT DRYING AIR TEMPERATURES

| | Coefficient and constants | | | | |
|---|---|---|---|---|---|
| Model | 40 ºC | 50 ºC | 60 ºC | 70 ºC | 80 ºC |
| Newton (Lewis) [10] | k=0.096 | k=0.163 | k=0.131 | k =0.223 | k=0.28 |
| Henderson and Pabis [19] | k=0.085, a=0.935 | k=0.109, a=0.844 | k=0.084, a=0.822 | k=0.095, a=0.741 | k=0.11, a=0.734 |
| Page [5], [12], [20], [23] | k=0.172, n=0.721 | k=0.331, n=0.552 | k=0.321, n=0.504 | k=0.455, n=0.424 | k=0.492, n=0.424 |
| Logarithmic [12], [20] | k=0.195, a=0.723, b=0.272 | k=0.383, a=0.707, b=0.271 | k=0.375, a=0.639, b=0.32 | k=0.568, a=0.643, b=0.293 | k=0.644, a=0.672, b=0.275 |
| Wang and Singh [12], [20] | k=-0.101, c=0.004 | k=-0.138, c=0.006 | k=-0.128, c=0.005 | k=-0.15, c=0.006 | k=-0.159, c=0.007 |
| Parabolic [23] | k=-0.101, a=0.858, c=0.004 | k=-0.09, a=0.852, c=0.003 | k=-0.091, a=0.769, c=0.004 | k=-0.089, a=0.952, c=0.003 | k=-0.096, a=0.754, c=0.004 |
| Midilli and Kucuk [9] | k=0.165, a=1.006, n=0.896, b=0.01 | k=0.349, a=1.028, n=0.723, b=0.012 | k=0.337, a=1.021, n=0.667, b=0.012 | k=0.494, a=1.03, n=0.583, b=0.012 | k=0.544 a=1.04, n=0.596, b=0.013 |
| Modified Henderson and Pabis [26] | k=0.085, a=1.062, b=-0.063, c=-0.063, g=0.085, h=0.085 | k=1.118, a=0.117, b=0.573, c=0.306, g=0.356, h=0.009 | k=0.011, a=0.375, b=0.546, c=0.072, g=0.39, h=2.753 | k=0.006, a=0.308, b=0.455, c=0.226, g=0.426, h=2.074 | k=0.11, a=0.856, b=-0.061, c=-0.061, g=0.11, h=0.11 |

TABLE III
COEFFICIENTS OF DETERMINATION, CHI-SQUARE AND ROOT MEAN SQUARE ERROR OF THE MODELS DEVELOPED USING DRYING DATA FOR VARIETY V139

| | $R^2$ | | | | | Chi-Square | | | | | Root mean square error | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | 40 ºC | 50 ºC | 60 ºC | 70 ºC | 80 ºC | 40 ºC | 50 ºC | 60 ºC | 70 ºC | 80 ºC | 40 ºC | 50 ºC | 60 ºC | 70 ºC | 80 ºC |
| Newton (Lewis) [10] | 0.937 | 0.768 | 0.662 | 0.457 | 0.497 | 0.004 | 0.015 | 0.017 | 0.027 | 0.022 | 0.063 | 0.120 | 0.129 | 0.161 | 0.146 |
| Henderson and Pabis [19] | 0.959 | 0.862 | 0.841 | 0.748 | 0.722 | 0.003 | 0.009 | 0.019 | 0.020 | 0.021 | 0.057 | 0.093 | 0.138 | 0.140 | 0.143 |
| Page [5], [12], [20], [23] | 0.989 | 0.968 | 0.970 | 0.953 | 0.940 | 0.001 | 0.004 | 0.003 | 0.005 | 0.004 | 0.036 | 0.063 | 0.052 | 0.072 | 0.065 |
| Logarithmic [12], [20] | 0.999 | 0.998 | 0.995 | 0.991 | 0.992 | 0.003 | 0.011 | 0.008 | 0.015 | 0.017 | 0.058 | 0.102 | 0.090 | 0.121 | 0.129 |
| Wang and Singh [12], [20] | 0.971 | 0.810 | 0.770 | 0.473 | 0.428 | 0.002 | 0.011 | 0.010 | 0.024 | 0.028 | 0.038 | 0.102 | 0.100 | 0.152 | 0.164 |
| Parabolic [23] | 0.918 | 0.913 | 0.843 | 0.983 | 0.824 | 0.001 | 0.005 | 0.005 | 0.010 | 0.010 | 0.033 | 0.072 | 0.067 | 0.098 | 0.100 |
| Midilli and Kucuk [9] | 0.998 | 0.997 | 0.995 | 0.994 | 0.995 | 0.000 | 0.002 | 0.000 | 0.002 | 0.001 | 0.010 | 0.047 | 0.022 | 0.049 | 0.024 |
| Modified Henderson and Pabis [26] | 0.959 | 1.000 | 0.998 | 0.999 | 0.722 | 0.001 | 0.002 | 0.001 | 0.002 | 0.005 | 0.032 | 0.044 | 0.037 | 0.047 | 0.072 |

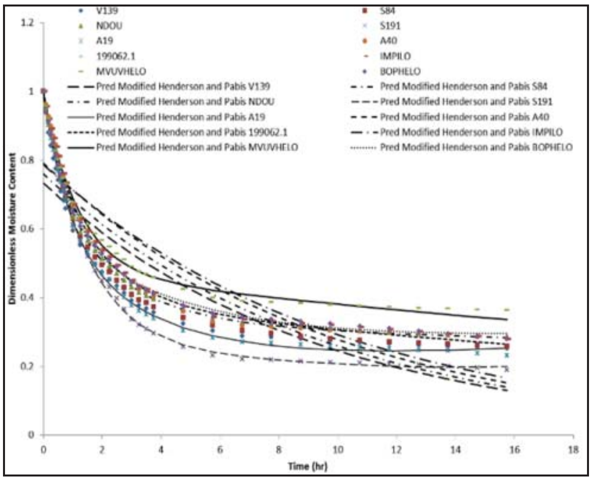


Fig. 11 Comparison between experimental and predicted moisture ratios using Modified Henderson and Pabis model for convective hot air drying of sweet potato slices as a function of drying time at 80°C

### C. Figures and Tables Effective Moisture Diffusivity

For the determination of effective moisture diffusivity of sweet potato slices, the solution to the equation developed by [35] was used. Therefore, for long drying period, this solution can be written in a logarithmic form as follows [12]:

$$MR = \frac{(M - M_e)}{M_o - M_e} = \frac{8}{\pi^2}\exp\left(\frac{-\pi^2 D_{eff} t}{4L_0^2}\right) \quad (3)$$

where $t$ is the drying time (s), $D_{eff}$ is the effective moisture diffusivity ($m^2/s$) and $L_0$ is the half thickness of the samples (m). Therefore,

$$Ln(MR) = \frac{-\pi^2 D_{eff}}{4L_0^2}t + \ln\frac{8}{\pi^2} \quad (4)$$

The Ln (MR) was plotted against time at different temperatures. The slope derived from the linear regression of the graphs was used to calculate the effective moisture diffusivity [12], [19]. The $D_{eff}$ is calculated from the slope obtained as:

$$\text{Slope} = \frac{-\pi^2 De_{ff}}{4L_0^2} \quad (5)$$

The values of the effective diffusivity coefficients of the sweet potato samples varied between 1.48 x $10^{-9}$ to 1.90 x $10^{-9}$ $m^2/s$ for V139; 1.43 x $10^{-9}$ to 1.93 x $10^{-9}$ $m^2/s$ for S84; 1.54 x $10^{-9}$ to 1.77 x $10^{-9}$ $m^2/s$ for NDOU; 1.93 x $10^{-9}$ to 2.47 x $10^{-9}$ $m^2/s$ for S191; 1.54 x $10^{-9}$ to 2.07 x $10^{-9}$ $m^2/s$ for A19; 1.59 x $10^{-9}$ to 1.85 x $10^{-9}$ $m^2/s$ for A40; 1.46 x $10^{-9}$ to 1.92 x $10^{-9}$ $m^2/s$ for 199062.1; 1.37 x $10^{-9}$ to 1.83 x $10^{-9}$ $m^2/s$ for Impilo; 1.34 x $10^{-9}$ to 1.79 x $10^{-9}$ $m^2/s$ for Mvuvhelo; and 1.27 x $10^{-9}$ to 1.77 x $10^{-9}$ $m^2/s$ for Bophelo. The values of $D_{eff}$ obtained for hot air ventilation drying characteristics for Bophelo (1.27 x $10^{-9}$ to 1.77 x $10^{-9}$ $m^2/s$) was the least while that of the S191 (1.93 x $10^{-9}$ to 2.47 x $10^{-9}$ $m^2/s$) had the highest value which indicates that moisture diffusivity in sweet potato is affected by the drying temperature. The range for the values obtained is in the range reported for agricultural food materials in literature for other food materials: 1.49 - 5.59 x $10^{-9}$ $m^2/s$ for kale [36], 3.72–12.27 x $10^{-9}$ $m^2/s$ for tomatoes dried at 45 to 75 °C [22]; 3.91 - 7.53 x $10^{-10}$ $m^2/s$ for tomatoes dried at 55 to 70 °C [15] and 2.22 - 4.69 x $10^{-10}$ $m^2/s$ for apples [18].

It was observed that $D_{eff}$ values increased with increase in temperature. The drying temperature has a significant effect on the internal mass transfer during drying. This is because the rate at which moisture diffuse from the internal regions to the surface occurs is a linear relationship with drying temperature. Thus surface water removal is faster at higher temperature since most of the drying mechanism is vapour diffusion. Similar results have been obtained for other agricultural crops like carrot garlic [30], mint leaves [13], date palm fruits [17], tigernut [19], and tomato slice [20]. This is probably due to the fact that water diffusion was mainly due to mass transport mechanism during the drying.

### D. Activation Energy

The Arrhenius Equation (6) was used for the determination of activation energy of the sweet potato slices. This is due to the dependence of the effective diffusivity on the different drying temperature which predicts appropriately using the equation [37]:

$$D_{eff} = D_o \exp\left(-\frac{E_a}{R(T+273.15)}\right) \tag{6}$$

where $D_0$ is the pre-exponential factor of Arrhenius equation or maximum diffusion coefficient (at infinite temperature) in $m^2/s$, $D_{eff}$ is the effective moisture diffusivity in $m^2/s$, Ea is the activation energy in kJ/mol, T is temperature in °C, and *R* is the universal gas constant in kJ/mol K.

Linearizing the equation gives:

$$LnDeff = \left(-\frac{1}{R(T+273.15)}\right)E_a + \ln D_o \tag{7}$$

The activation $E_a$ was obtained by plotting

$$\text{Ln } D_{eff} \text{ against } \left(-\frac{1}{R(T+273.15)}\right) \tag{8}$$

The activation energy was obtained from a graph of Ln $D_{eff}$ versus 1/Tabs (Fig. 12) and calculation using (8). The activation energy value obtained ranged from 0.27-6.54 kJ/mol for all the sweet potato slices considered. The activation energy is a measure of the temperature sensitivity of $D_{eff}$ and it is the energy needed to initiate the moisture diffusion within the seed. The activation energy value for sweet potato slice drying indicates that the energy required to initiate moisture diffusion is low. This value is slightly lower than that of 8.831 kJ/mol for blanched yam slices [38], and lower than that of 19.79 kJ/mol for *Agaricus bisporus* mushrooms [39].

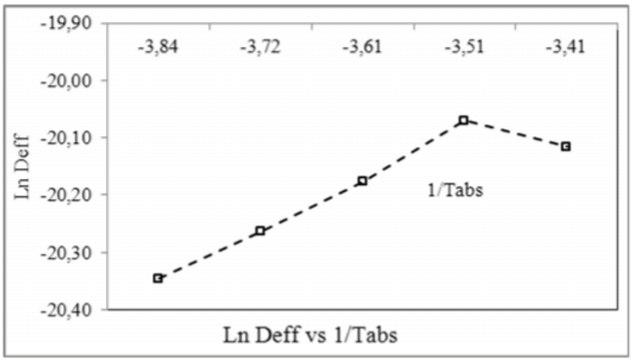


Fig. 12 Ln ($D_{eff}$) versus 1/Tabs for convective hot air drying of 199062.1 variety of sweet potato slices

## IV. Conclusion

Convective hot air drying of different varieties of sweet potato slices at different drying temperatures (40-80°C) was investigated. Drying time decreased considerably with increase in air temperature. Drying took place in a constant rate period followed by the falling rate period after a short heating period. The results of fitting the drying data to the eight thin layer drying models showed that the Modified Henderson and Pabis model was found to be the most suitable for describing the drying curves of all the sweet potato slices at the drying air temperature considered. This is done in order to optimise coefficients. The values of $D_{eff}$ obtained for drying characteristics of Bophelo variety (1.27 x $10^{-9}$ to 1.77 x $10^{-9}$ $m^2/s$) was the least while that of the S191 (1.93 x $10^{-9}$ to 2.47 x $10^{-9}$ $m^2/s$) had the highest value which indicates that moisture diffusivity in sweet potato is affected by the drying temperature and variety. The activation energy value ranged from 0.27-6.54 kJ/mol expressed effect of temperature on the diffusivity. The lower activation energy for moisture diffusion of sweet potato slices compared to some agricultural and food (paddy rice, barley, wheat, pistachio nut and tiger nut) indicates that drying of sweet potato slices requires less energy and is hence a cost and energy saving method compared to the drying of other products. This makes the drying of sweet potato slices an advantage considering the level of poverty among the majority of the populace that is into sweet potato processing.

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