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RESEARCH ARTICLE

MODELING OF THE KINETICS OF DRYING OF GAMBOMA PRETREATED YAM *(DIOSCOREA CAYENENSIS)*

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ABSTRACT

The outcomes of this work are firstly to study the influence of operatory parameters (drying temperature, the thickness of yam slices, the treatment with ascorbic acids (AA) and benzoic (AB) on the effective diffusivity during *Dioscorea cayenensis* yam, and secondly to model the drying kinetics according to the semi-empirical approach, by using the models of Henderson and Pabbis, the model of Page, the model of Wang and Singh, and the model of Two terms. As a result, temperature and thickness of thin layers are two main parameters having significant effects on the diffusion coefficient during drying. The increasing of drying temperature from 50 to 90°C for drying slices of thickness E= 4.76 mm increases the diffusion coefficient from $1.685\times 10^{-11}$to 4.57×10^{-11} m^2s^{-1}. For a slice thickness (E= 4.65 ±0,15 mm), or an increasing of effective diffusivity of factor 2, 712.The influence of cutting thickness has been also noticed on the variation the effective diffusivity. Then the diffusion coefficient increases from 9.45×10^{-12} to 4.57×10^{-11} $m^2.s^{-1}$ for the thickness increase from 1.87 to 4.76 mm or an increase of factor 4.836. Yet we remark a feeble difference between treated slices and non-treated slices. The drying kinetics modeling reveals us the values R^2, of reduced ki-square and RMSE vary respectively from $0.94059 \leq R^2 \leq 0{,}99985$, $0.000023 \leq \chi^2 \leq 0.01019$ et $0.000138 \leq RMSE \leq 0.684400$. Among the four (4) models tested in all experimental conditions, the PLAGE mode describes better the drying kinetics of yam slices with R^2= 0.99985, χ^2= 0.000023 and RMSE = 0.000138 (a yam sample of 1.87 mm thickness treated with ascorbic acid at 2% and dried at 90 °C).

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INTRODUCTION

Food security remains one of the major problems in many developing countries. In sub-Saharan Africa the roots and yams constitute the most important food crops. These roots and yams are object particular studies in order to valorize and diversify the economies of most of tropical subtropical countries (Kouassi, 2009). Yams belong to the *Dioscorea* type in which we have more 600 species (Coursey, 1967) share out in the wet inter tropical, but very few in the temperate regions. Among those species, only the *Dioscorea alata* and the complex *Dioscorea cayenensis – rotundata* are object of large scale farming and present a real economic importance especially in Africa. In Africa, the African complex *Dioscorea cayenensis – rotundata* is the most important and represents more than 96 % of the total production (Babajide *et al*., 2010). The yam is made of 50 to 80 % water (% reported to the wet matter), and composed of 90 % feculent and carbon hydrates (% reported to the dry matter), of 5% proteins, of 1% mineral elements, and of 0.5% of fibers (Degras, 1986).

The drying which one of the techniques of conservation of agricultural products, remains a primordial means of yam conservation. It is a technique of eliminating the water which implies the transfer of heat and mass transfer. The drying process exercises a strong influence, not only on the rheological properties (deformation, surface state…..), but also on the nutritional properties of the product to dry (Kechaou *et al*., 1996). The drying mastership implies necessarily an aptitude to predict, any time, the evolution of the physical characteristics of drying such as water rate of the product. This aptitude can be obtained with the help of the modeling (Nogbou *et al.,* 2015)**.**Therefore it is evident to think that the combination of the thickness effects of slices, the treatment to ascorbic acid (AA), and benzoic (AB) and drying temperature would influence the kinetic parameters of diffusion, and so the curve state. Many mathematical models have been used to describe the drying process. They can be classified in theoretical models, semi empirical models and empirical models (Prati, 1990). The theoretical models, according to their complexity, give fine details of transfer mechanism. Unfortunately, the difficulty to get certain parameters, limits sometimes their utilization. At present, most of the kinetics drying models of the several products belongs to semi

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empirical domains (Nasfi and Bagane., 2017 ; Nogbou *et al.,* 2015 ; Thu Ha Nguyen., 2015 ; Messaoudi *et al.*, 2015 ; Jannot *et al.,* 2006). The modeling of drying kinetics of yam thin layers *Dioscorea cayenensis* has been made following the semi empirical approach, leaning on the adjustment of the experimental data to data predicted by four (4) models: the model of Henderson and Pabbis, the Page model, the Wang and Singh model and the Two terms model. The smoothness quality has been checked by some statistical parameters such as the determination coefficient (R^2), the average quadratic error (RMSE), and the chi-square.

MATERIALS AND METHODES

Vegetable material and sampling

The yams *Dioscorea cayenensis* have been bought at Total market in Brazzaville. They have been stocked in the laboratory at room temperature during all the period of experience. The yams of mass 474.17 ± 131.53 g of 25.57 ± 3.59 cm length and 18.38 ± 3.51 cm circumference have been used to constitute our sampling. The yams have been washed and pealed with a knife. Then the pealed yams have been put into slices of thickness 1.87; 2.60; 4. 54; 4.76 mm, of 4 cm long and 3 cm large, well defined with the help of an electric slicer RCL1 and pretreated with ascorbic acids and benzoic at 0%, 0.75% and 2% at 50°C during 30 minutes. The samples have been code as following: T-X/Y/Z, with: T = type of treatment (AA: ascorbic acid, AB: benzoic acid, ST: without treatment); X = acid concentration in %; Y = slices thickness in mm; Z = drying temperature in ^{o}C).

Steam Drying

It is a technique of reference imposed in the many substances. It has a good reproducibility. The advantage of this classical method resides in the great number of samples which can be analyzed simultaneously. The drying of slices has been made at temperatures of 50 and 90 ^{o}C in the steamer of brand INDELAB(0-250°C). With the help of a precision scales of brand EXPLORER-PRO (0-210g, with e= 0.0001g)**,** the mass of the samples has been watched in time until it does no more vary within three (3) successive measurements.

Determination of the parameters of the drying kinetics

Tenor in water: The determination of the tenor in water has been done according to the AOAC method (1990) based upon the loss of the mass of samples after steaming à 105 ± 2 °C until total elimination of free water and volatile matters.

The tenor in water is calculated using the equation (1)

$$X= [(m_d-m_w) / m_d] \times 100 \qquad (1)$$

X = tenor in water reported to wet mass
M_w= mass of the wet sample
M_{d} = mass of the dry sample

Effective diffusivity (D_{eff}): The transfer of matter during drying is controlled by internal diffusion. The second law of FICK of diffusion shown in equation (2) has been widely used to describe the drying process of most biologic products (Srikiatden *et al*., 2008). The diffusion coefficient of yam thin layers has been determined from the analytic equation of the second FICK law, developed by Crank (1975). Supposing that transfers are one-dimensional, the tenor in water initially uniform in the product without contraction of the solid matter and a long time of diffusion. The analytic solution of FICK equation according to the geometric form of the sample ((parallelepiped) is given by the following equation:

$$X^* = (X_{(t)}-X_{eq}) / (X_0-X_{eq}) = 8/(\pi)^2 \exp [(\pi^2 \times D_{eff} / 4L^2)\times t] \qquad (2)$$

X*: reduced tenor in water
$X_{(t)}$:(g.g^{-1}.$_{MS}$) : instantaneous tenor in water
X_0 : (g. g^{-1}.$_{MS}$): initial tenor in water
X_{eq} : (g.g^{-1}.$_{MS}$): balanced tenor in water
D_{eff} (m^2s^{-1}): effective coefficient of diffusion
L (m) :mid- thickness of the sample
t (s): drying time

The reduced tenor in water has been simplified by equation (3), because X_{eq} is relatively negligible compared to $X_{(t)}$ and X_0 (Akmel *et al.,* 2009; Haoua, 2007).

$$X^* = X(t) / X_0= 8/(\pi)^2 \exp [(\pi^2 \times D_{eff} / 4L^2) \times t] \qquad (3)$$

$$\mathrm{Ln}\,(X^*) = \mathrm{Ln}\,(8/\pi^2) -[(\pi^2 \times D_{eff} \times t) /4L^2] \qquad (4)$$

The effective coefficient of diffusion is then calculated from the graphic bearing in abscise the drying time and in ordinates Ln (X*). The slop of the regression line giving Ln (X*) with regard top time permits to calculate the diffusion coefficient of the humidity as following:

$$(\pi^2 \times D_{eff})/4L^2 =K.\ D_{eff}= (4L^2 \times K)/\pi^2 \qquad (5)$$

with K : slop

Modeling the drying curves

Many mathematic models have been proposed in literature to describe to describe the drying process. We can class them in theoretical, semi empirical and empirical models (Prati, 1990). The theoretical models, in the complexity, detail finely the transfer mechanism; unfortunately the difficulty to get some parameters limits sometimes their utilization (Nogbou *et al*., 2015). The semi empirical models, for good adjustment reasons between experimental data and predicted data by the models and their facility to determine the coefficients, they are largely used in the drying works, particularly in the description of the behavior of water in the product (Murthy and Manohar, 2012; Hii *et al*., 2008). Four (4) semi empirical models (table 1) have been chosen to model the steam drying kinetics of yams thin layers after pretreatments to ascorbic and benzoic acids. The choice of the best model is based upon the value of the determination coefficient (R^2) increased, and Ki-square (χ^2) reduced and their root square of the average quadratic error (RMSE), the lowest (Doymaz, 2004). In this study, the nonlinear or linear regression analysis was performed with statistical software, Origin Pro 2016

The statistic parameters of models adjustments

Coefficient of determination (R^2)

$$R^2=1-[\Sigma^{N}_{i=1} (X^*_{ei} -X^*_{pi})^2]/[\ \Sigma^{N}_{i=1} (X^*_{m} -X^*_{pi})^2] \qquad (6)$$

Averagequadratic erre (RMSE)

$$RMSE= [(1/N)\times\Sigma^{N}_{i=1} (X^{*}_{ei} - X^{*}_{pi})^{2}]^{1/2} \quad (7)$$

Chi-square

$$\chi^{2}= 1/(N-n)\times\Sigma^{N}_{i=1} (X^{*}_{ei} - X^{*}_{pi})^{2} (8)$$

Where:

$(X^{*}ei,)$ $i^{ème}$ experimental value,

$X^{*}pi$ $i^{ème}$ predicted value by the model,
$X^{*}me$, average experimental values
N, number of observations,
n, number of model constants

RESULTS AND DISCUSSION

Effective diffusivity

The results of the influence of drying temperature the thickness of yams thin layers and the treatments to ascorbic acid (AA) and benzoic acid (AB) on the effective diffusivity during the drying of yam *Dioscorea cayenensis* are presented in the Fig. 1, 2 and 3. The comparative study of the obtained results with treated thin layers to ascorbic and benzoic acids, and non treated ones, don't reveal any significant differences on the coefficient of the diffusion (Fig.1). As illustration, for the thin layer of thickness E= 2,60 mm and dried at 50°C , the coefficient of diffusion vary respectively from 7.76×10^{-12} $m^{2}s^{-1}$ for the non treated, from 7.96×10^{-12} $m^{2}s^{-1}$ for treated thin layers to ascorbic acid at 2% et 8.25×10^{-12} $m^{2}s^{-1}$, for the treated thin layers to benzoic acid to 2%. Therefore, the presence of molecules of ascorbic and benzoic acids within the yam thin layer to 2% does not modify general the drying phenomenon. In fact, the pretreatments are done so that the effective diffusivity of the product after pretreatment might be superior the effective diffusivity of the product without pretreatment (Goyal *et al.,* 2007; Agarry *et al.,* 2013). The results are similar to those obtained by Lahnine (2015) and Silou *et al* (1991). The influence of the drying temperature and the thickness of the yam thin layers of the coefficient of diffusion are presented in the Fig. 2 and Fig. 3. We can remark that the variation of the drying temperature from 50 to 90°C increases the coefficient of diffusivity of 1.69×10^{-11} à 4.57×10^{-11} $m^{2}.s^{-1}$ for a thickness of thin layers (E=4.65 ±0.15 mm).Yet the augmentation of the thickness of thin layers of 1.87 à 4.76 mm makes the diffusivity vary from 3.80×10^{-11} to 4.57×10^{-11} $m^{2}s^{-1}$ (T=90°C). The diminution of the thickness of the thin layers and the increasing of the drying temperature result in the increase of the coefficients of exchange of heat and matters. In fact the increase temperature leads to the agitation of the molecules and consequently and increase of the coefficient of diffusion. The drying kinetics is therefore as fast as the temperature is high. These results show that the coefficient vary essentially with the drying temperature and the thickness of the cutting in layers as illustrated by Messaoudi *et al.*, (2015); Dissa *et al.*, (2007); Lacerba et *al.*, (2005); Chirife, (1983); Fahloul et *al.*, (2009); Park *et al.,* (2002); Umesh Hebbar *et al.,* (2001).

Modeling the drying kinetics

The influence of the drying temperature, the thickness of the thin layers, the pretreatment to ascorbic and benzoic acids during drying have been studied.

Table 1. Mathematical models

Models	Equations	References
Henderson et Pabbis	$X^{*} = a^{*}\exp (-k^{*}t)$	Akmel et *al*., (2009)
Page	$X^{*}=\exp (- k * t^{n})$	Sharma and Prasad (2001)
Wang et Singh	$X^{*} = 1 +a^{*}t + b^{*}t^{2}$	Wang and Singh (1987)
Two terms	$X^{*}=a *\exp (- k_{1}* t)+ b^{*}\exp (-k_{2}^{*}t)$	Henderson (1974)

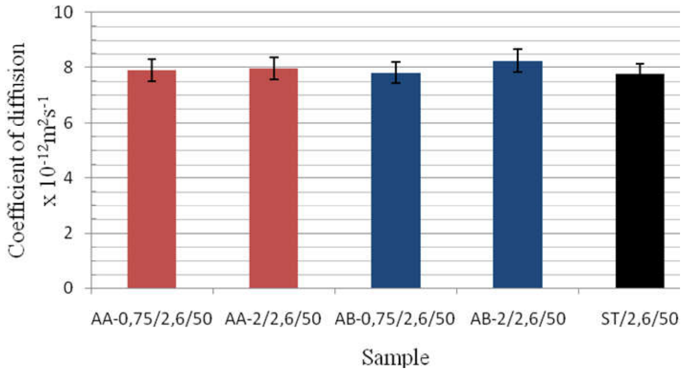


Fig. 1. Influence of the parameters to ascorbic and benzoic acids up on the coefficient of effective diffusion (T=50°C, E=2, 6 mm and Xo= 55 -67%)

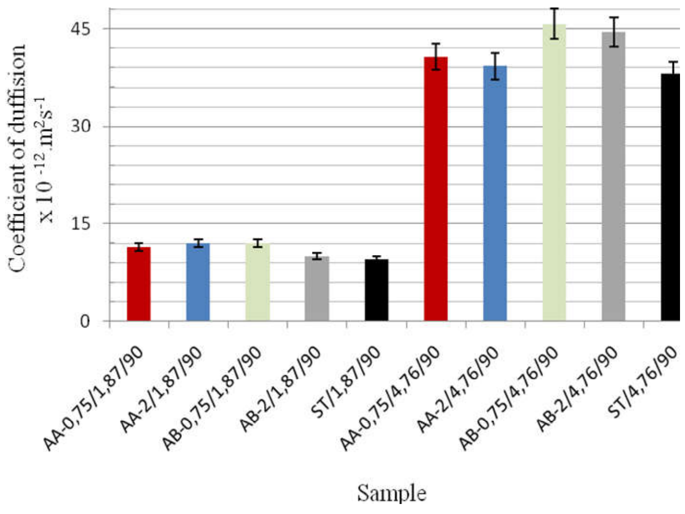


Fig. 2. Influence of the slices thickness on the coefficient of effective diffusion (T=90°C, E=1,87 mm and E=4,76 mm, Xo= 55 -67%)

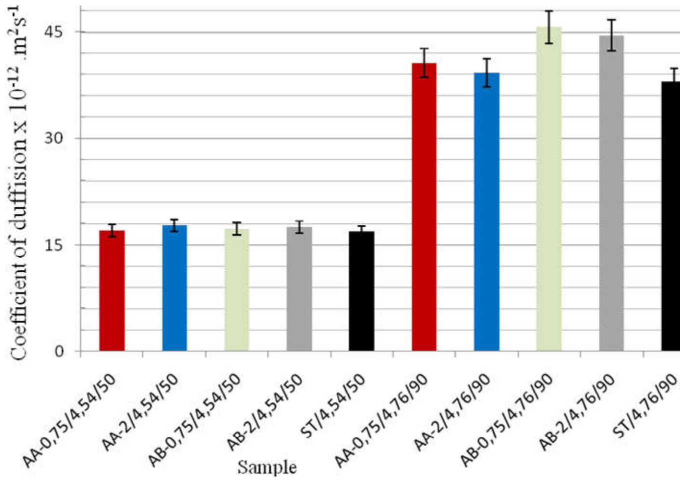


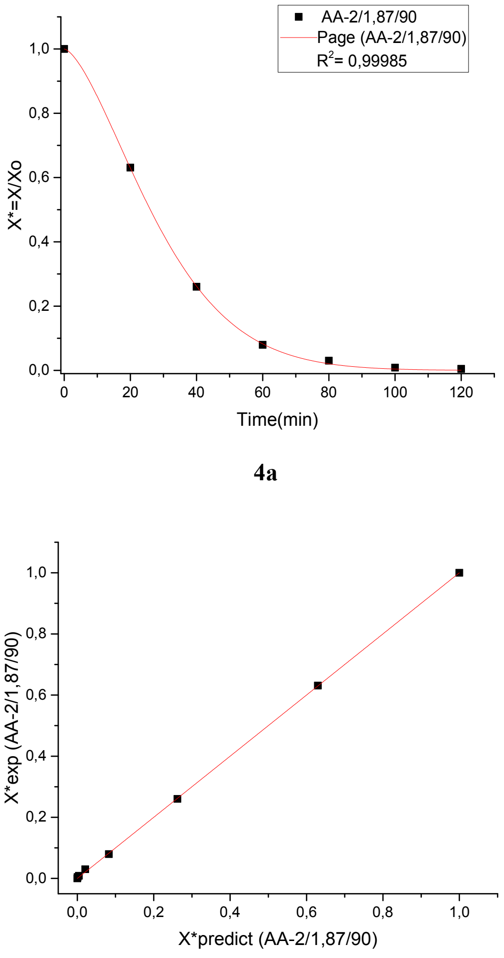
Fig. 3. Influence of the drying temperature (T= 50 °C and T=90°C) on effective diffusion coefficient (E=4,65 ±0,15 mm, Xo= 55 -67%)

The results of curves simulations related to the water tenor reduced according to time of the four semi empirical models (the model of Henderson and Pabbis, the model of Page, the model of Wang and Singh and the model of two terms) are presented in Table 2.

Table 2. Statistiscal results of differents drying models for Gamboma pretreated Yam (*Dioscorea cayenensis)*

Samples	Models	Models constants					Standard of modelization		
		a	b	k_1	k_2	n	R^2	RMES	χ^2
AA-0.75/2.6/50	Henderson and Pabbis	1.07556	-	0.00779	-		0.95578	0.07134	0.00792
AA-0.75/2.6/50	Page	-	-	0.0004	-	1.673	0.99139	0.01034	0.00115
AA-0.75/2.6/50	Wang and Singh	-0.006	4.6E-06				0.99841	0.00556	-
AA-0.75/2.6/50	Two terms	0.54776	0.54776	0.01039	0.01039		0.94059	0.07134	0.01019
AA-2/2.6/50	Henderson and Pabbis	1.08442	-	0.01142	-	-	0.95458	0.05481	0.00608
AA-2/2.6/50	Page	-	-	0.00048	-	1.547	0.99214	0.00948	0.00105
AA-2/2.6/50	Wang and Singh	-0.0071	0.00001	-	-	-	0.99894	0.00342	-
AA-2/2.6/50	Two terms	0.8877	0.19669	0.01142	0.01141	-	0.95458	0.05481	0.00783
AB-0.75/2.6/50	Henderson and Pabbis	1.09175	-	0.01066	-	-	0.9506	0.05853	0.0065
AB-0.75/2.6/50	Page	-	-	0.00071	-	1.5579	0.98915	0.01286	0.00143
AB-0.75/2.6/50	Wang and Singh	-0.0064	6.3E-06	-	-	-	0.99924	0.00264	-
AB-0.75/2.6/50	Two terms	0.17948	0.91221	0.01065	0.01065	-	0.9506	0.05853	0.00836
AB-2/2.6/50	Henderson and Pabbis	1.10023	-	0.01154	-	-	0.95655	0.05399	0.006
AB-2/2.6/50	Page	-	-	0.00068	-	1.5893	0.99609	0.00485	0.000054
AB-2/2.6/50	Wang and Singh	-0.0072	0.00001	-	-	-	0.99815	0.00611	-
AB-2/2.6/50	Two terms	0.25554	0.84462	0.01153	0.01154	-	0.95656	0.0599	0.00771
ST/2.6/50	Henderson and Pabbis	1.06888	-	0.01078	-	-	0.95109	0.05581	0.0062
ST/2.6/50	Page	-	-	0.00097	-	1.5014	0.9862	0.1571	0.0017
ST/2.6/50	Wang and Singh	-0.0068	8.4E-06	-	-	-	0.99898	0.00337	-
ST/2.6/50	Two terms	0.84203	0.22678	0.01078	0.01078	-	0.9511	0.5881	0.00797
AA-0.75/1.87/90	Henderson and Pabbis	1.0119	-	0.0311	-	-	0.99621	0.00336	0.000056
AA-0.75/187/90	Page,	-	-	0.01742	-	1.1521	0.99888	0.00098	0.00016
AA-0.75/1.87/90	Wang and Singh	-0.0195	0.00009	-	-	-	0.98706	0.01866	-
AA-0.75/1,87/90	Two terms	0.54056	0.47134	0.03109	0.0311	-	0.99621	0.00336	0.00084
AA-2/1.87/90	Henderson and Pabbis	1.03475	-	0.03327	-	-	0.99156	0.01781	0.001968
AA-2/1.87/90	Page	-	-	0.00468	-	1.5334	0.99985	0.00014	0.000023
AA-2/1.87/90	Wang and Singh	-0.0204	0.00009	-	-	-	0.9859	0.02077	-
AA-2/1.87/90	Two terms	0.36173	0.67301	0.03326	0.03327	-	0.98156	0.01781	0.004452
AB-0.75/1,87/90	Henderson and Pabbis	1.02269	-	0.03566	-	-	0.98994	0.0093	0.00155
AB-0.75/1.87/90	Page	-	-	0.00895	-	1.3817	0.99982	0.00017	0.000028
AB-0.75/1.87/90	Wang and Singh	-0.021	0.0001	-	-	-	0.97853	0.02975	-
AB-0.75/1.87/90	Two terms	0.34884	0.67382	0.03566	0.03565	.	0.98985	0.0093	0.002325
AB-2/1.87/90	Henderson and Pabbis	1.03378		0.02757	-	-	0.98972	0.01212	0.002019
AB-2/1.87/90	Page	-	-	0.00712	-	1.3662	0.99946	0.00051	0.000085
AB-2/1.87/90	Wang and Singh	-0.0182	0.00008	-	-	-	0.99597	0.00649	-
AB-2/1.87/90	Two terms	0.1707	0.86305	0.02756	0.02756	-	0.98717	0.01212	0.003029
ST/1.87/90	Henderson and Pabbis	1.04205	-	0.02602	-	-	0.98385	0.00256	0.00256
ST/1.87/90	Page	-	-	0.00543	-	1.3973	0.99867	0.00127	0.00021
ST/1.87/90	Wang and Singh	-0.0175	0.00007	-	-	-	0.9945	0.00932	-
ST/1.87/90	Two terms	0.39768	0.64434	0.02602	0.02602	-	0.98384	0.01534	0.003834
AA-0.75/4.54/50	Henderson and Pabbis	1.07556	-	0.00779	-	-	0.95578	0.06501	0.005
AA-0.75/4.54/50	Page	-	-	0.00081	-	1.4389	0.98498	0.02207	0.00169
AA-0.75/4.54/50	Wang and Singh	-0.0049	4.6E-06	-	-	-	0.99913	0.0038	-
AA-0.75/4.54/50	Two terms	0.53776	0.53776	0.00779	0.00779	-	0.95578	0.06501	0.00591
AA-2/4.54/50	Henderson and Pabbis	1.087	-	0.00809	-	-	0.95816	0.064	0.00492
AA-2/4.54/50	Page	-	-	0.00065	-	1.488	0.99088	0.01395	0.00107
AA-2/4.54/50	Wang and Singh	-0.0051	0.00005	-	-	-	0.99945	0.00237	-
AA-2/4.54/50	Two terms	0.54345	0.53346	0.00809	0.00809	.	0.95815	0.064	0.00581
AB-0.75/4.54/50	Henderson and Pabbis	1.09789	-	0.00785	-	-	0.9553	0.06901	0.005308
AB-0.75/4.54/50	Page	-	-	0.00049	-	1.5335	0.99149	0.01313	0.001009
AB-0.75/4.54/50	Wang and Singh	-0.0049	4.1E-06	-	-	-	0.99917	0.00375	-
AB-0.75/4.54/50	Two terms	0.4874	0.4904	0.00785	0.00784	-	0.9553	0.06901	0.00627
AB-2/4.54/50	Henderson and Pabbis	1.08207	-	0.00792	.-	-	0.95629	0.06569	0.00505
AB-2/4.54/50	Page	-	-	0.00073	-	1.461	0.98702	0.01951	0.0015
AB-2/4.54/50	Wang and Singh	-0.005	4.7E-06	-	-	-	0.99936	0.0028	-
AB-2/4.54/50	Two terms	0.541	0.541	0.00792	0.00792	-	0.9562	0.06569	0.00597
ST/4.54/50	Henderson and Pabbis	1.08868	-	0.00774	-	-	0.95452	0.6844	0.00526
ST/4.54/50	Page	-	-	6E-06	-	1.4741	0.98568	0.02154	0.00165
ST/4.54/50	Wang and Singh	-0.0047	0.000004	-	-	-	0.99901	0.00445	-
ST/4.54/50	Two terms	0.05361	1.03501	0.00775	0.00774	-	0.95452	0.06844	0.00622
AA-0.75/4.76/90	Henderson and Pabbis	1.06552	-	0.01642	-	-	0.96886	0.03227	0.00461
AA-0.75/4.76/90	Page,	-	-	0.00221	-	1.4505	0.99566	0.00447	0.00063
AA-0.75/4.76/90	Wang and Singh	-0.0108	0.00003	-	-	-	0.99959	0.00098	-
AA-0.75/4.76/90	Two terms	0.46517	0.60024	0.01642	0.01642	-	0.96866	0.03227	0.00645
AA-2/4.76/90	Henderson and Pabbis	1.05228	-	0.01586	-	-	0.96785	0.03182	0.00454
AA-2/4.76/90	Page	-	-	0.00277	-	1.3905	0.99067	0.00922	0.001317
AA-2/4.76/90	Wang and Singh	-0.0105	0.00003	-	-	-	0.99974	0.00063	-
AA-2/4.76/90	Two terms	0.42228	0.62992	0.01586	0.01585	-	0.96784	0.03182	0.006363
AB-0.75/4.76/90	Henderson and Pabbis	1.03567	-	0.01873	-	-	0.98335	0.01635	0.002335
AB-0.75/4.76/90	Page	-	-	0.00277	-	1.3905	0.99068	0.00922	0.00132
AB-0.75/4.76/90	Wang and Singh	-0.0102	0.000024	-	-	-	0.9994	0.00058	-
AB-0.75/4.76/90	Two terms	0.62546	0.41017	0.01872	0.01873	-	0.98335	0.01635	0.003269
AB-2/4.76/90	Henderson and Pabbis	1.04852	-	0.018	-		0.97735	0.02291	0.003273
AB-2/4.76/90	Page	-	-	0.00409	-	1.3382	0.99435	0.00572	0.000816
AB-2/4.76/90	Wang and Singh	-0.0122	0.00004	-	-	-	0.99981	0.00041	-
AB-2/4.76/90	Two terms	0.64368	0.40476	0.018	0.01799	-	0.97736	0,02291	0.004582
ST/4.76/90	Henderson and Pabbis	1.07214	-	0.01543	-	-	0.9619	0.03921	0.0056
ST/4.76/90	Page	-	-	0.00116	-	1.4948	0.99363	0.00655	0.00093
ST/4.76/90	Wang and Singh	-0.0098	0.00002	-	-	-	0.99959	0.00103	-
ST/4.76/90	Two terms	0.07201	0.35197	0.01542	0.01543	-	0.9619	0.03921	0.00784

The results show that the four models adjust well the drying kinetics of the drying of the yam thin layers at different operatory conditions. The values R^2 and reduced Ki-square and the RMSE vary respectively from $0.94059 \leq R^2 \leq 0.99985$, $0.000023 \leq \chi^2 \leq 0.01019$ and $0.000138 \leq RMSE \leq 0.684400$. Among the four models, the Page model gives the value of the highest coefficient of determination (R^2=0.99985) and of ki-square (χ^2= 0, 000023) and RMSE (RMSE = 0, 000138) the weakest for the sample of yam thin layers of thickness 1.87 mm treated with ascorbic acid 2% and dried at 90 °C with a coefficient of diffusion $D_{eff}=1.21\times 10^{-11}\ m^2.s^{-1}$ (Fig. 4).



4a

4b

Figure 4 (a, b). Numeric analysis of Page model applied to the sample AA-2/1,87/90

Through a careful analysis of the results, we can remark that the samples dried at low temperature (T= 50°C) no matter the operatory conditions (thickness of thin layers, type of treatment), have as best model, the model of Wang and Singh. This Wang and Singh model describes very well the drying kinetics of the thin layers with a percentage 100% of best models ($0.99901 \leq R^2 \leq 0.99945$) among a total of 10 samples dried at 50 °C. The increase of the temperature from 50 to 90 °C decreases this rate of 50% with a coefficient of correlation from 0.9994 to 0.99981 for samples dried at high temperature (T=90°C) with a thickness comprised between 1.87 and 4.76 mm. The Page model comes in the second position of best model after that of Wang and Singh with R^2comprised between 0.99067 and 0.99985 for samples treated in the same conditions (T= 90°C, thickness between 1.87 and 4.76 mm). The adjustment of the drying kinetics by Page model has been identified in most of works as among the best models to describe the drying kinetics of vegetable products. These results agree with those obtained by (Chen, 2007); Nogbou *et al*., (2015).

Conclusion

The influence of the drying temperature, thickness of thin layers, and pretreatments to ascorbic and benzoic acids of yam *Dioscoreacayenensi* son the drying kinetics has been studied. The drying temperature and the thickness of cutting of thin layers are two main factors which affect the effective diffusivity of yam during drying. The effect of pretreatment to ascorbic and benzoic acid is not significant on effective diffusivity. The kinetics modeling with the tested models show a good adjustment of drying curves with statistic parameters respectively of $0.94059 \leq R^2 \leq 0.99985,\ 0.000023 \leq \chi^2 \leq 0.01019$ and $0.000138 \leq RMSE \leq 0.684400$. The equation of Wang and Singh remains the best for the drying at low temperature (T=50°C)no matter the size of cutting in thin layers. Among all models simulated, the Page model remains the one which describes a better drying kinetics in thin layers of yam *Dioscoreacayenensis.* With R^2=0.99985, χ^2=0.000023 and RMSE=0.00013.

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