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Kinetics drying of *Spirulina platensis*

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***Spirulina platensis* is a blue-green multicellular photosynthetic cyanobacterium and it is used in many countries as human and animal feed. The aim of this work is to determine and set kinetics drying for *S. platensis* at different temperatures (30, 40, 50 and 60°C). A completely randomized design was adopted and the treatments were the drying temperatures. *S. platensis* was furnished by the company, Brasil Vital, located in Anápolis – Goiás. The initial water content from the product was determined according to analytical norm from Association of Official Analytical Chemists (AOAC). The product was subjected to drying in a heater at temperatures of 30, 40, 50 and 60°C. The samples were placed on stainless steel removable trays with background screen; they consisted of three replications. The temperature and relative humidity from the air in the environment were monitored with a thermo-hygrometer. During the process of drying, the trays with samples were periodically weighed to obtain a constant weight. Afterwards, the math models were set on the experimental drying data, using Statistica 12.0 software. The criteria for the selection of the estimative statistics were: R^2 close to 100%, P < 10% and SE close to zero. The effective diffusion coefficient was obtained from the mathematical model of liquid diffusion. One can conclude that the necessary time for *S. platensis* to reach constant weight was 7.00, 4.58, 3.83, and 3.25 h, at temperatures of 30, 40, 50, and 60°C, respectively. The recommended model used to predict the drying phenomenon for *S. platensis* was the Midilli Mathematical model at temperatures of 30, 40, and 50°C, and the model Approach of Diffusion at temperature of 60°C. The diffusion coefficient increased with increased temperature; its values were from 3.343×10^{-8} to 14.881×10^{-8} m^2 s^{-1} at temperature ranging from 30 to 60°C. It activates energy for liquid diffusion at 39.52 $kJ.mol^{-1}$.**

Key words: Post-harvest, water content, microalgae.

INTRODUCTION

Microalgae are microorganisms that grow in a liquid environment. They multiply fast and are capable of performing oxygen photosynthesis, producing a biomass rich in compounds that are biologically active (Mendonça et al., 2014).

Spirulina platensis is a blue-green multicellular photosynthetic cyanobacterium. It has high protein content within its biomass (50 to 70%), essential fatty acid γ-linolenic among many other compounds (Bezerra, 2010). It is used in many countries in aquaculture, as human and animal feed, for pigment extraction, biofuel production, and as pollutant removal (Adiba et al., 2011).

In post-harvest phase, drying is the most applied process to ensure quality and stability of the product, taking into account that as water decreases within the material, it reduces the biologic activity and the chemical and physical changes that occur during storage (Ullmann et al., 2010). Air is used in the drying process as a means of heat conduction and transfers excess water from the feed to the atmosphere. Low humidity in the product allows its storage for long periods, besides its monetary valuation. However, if drying is not well done, the product might decay during storage (Domenico and Conrad, 2015).

Studying of the drying process is of great importance to make one know the phenomenon of energy and mass transfer within the product and the drying environment, which are fundamental to elaborate projects, operation and simulation of drying systems and dryers (Corrêa et al., 2010).

The drying curves vary according to product, species, variety, environmental conditions and post-harvest preparation methods, among other factors (Resende et al., 2010). In order to perform a simulation process, it is necessary to apply a mathematic model that best describes the drying situation of a given product. Besides performing the drying forecast, it is possible to analyze, though models, other variables such as temperature, relative humidity, etc. (Domenico and Conrad, 2015). Therefore, it is of undeniable importance to set different mathematic models for the experimental data of drying, and also, that new studies take place to know the most adequate model for a given product (Radünz et al., 2011).

Amongst the applied theoretical models in the drying process, diffusion method is the one which is intensively investigated. For a diffuse model to be used in the description of the kinetics of drying of a product, the diffusion equation must be resolved. The solution for the diffusion equation, in various situations of interest, requires the need to establish a hypothesis for the physical description (Silva et al., 2013). Besides the mathematical settings of the drying curves, the values from the effective diffusivity and energy activation are also fundamental for the project and the construction of drying equipment (Celma et al., 2009).

Taking into account the importance of theoretical study and the limitations of the information regarding the phenomena that occur during drying, mainly, of products classified as “new foods”, this study aims to determine and set the kinetics of drying for the microalgae, *S. platensis* at different temperatures (30, 40, 50 and 60°C).

MATERIALS AND METHODS

The experiment was conducted at Laboratory of Drying and Storage of Vegetable Products of Campus Anápolis of Exact and Technological Sciences Henrique Santillo, State University of Goiás located in Anápolis - Goias.

The microalgae, *S. platensis* was furnished by the company Brazil Vital, located in Anápolis – Goias. The geographical coordinate of the county is at latitude 19’ 43” south and longitude 48° 57’ 12” west, in the State of Goias. The company furnished filtered samples. Afterwards, the samples were pressed into cylindrical pellets of 0.002 m thickness.

The treatment was the drying temperatures (30, 40, 50 and 60°C), consisting of three replications. Temperatures above 60°C were not chosen, for studies show that temperatures above the aforementioned have a negative effect on the nutritional composition of *S. platensis* (Bennamouna et al., 2015).

The initial water content of *S. platensis* was determined according to the analytical norm AOAC (1995) of 105°C up to constant mass, with three replications

The product was subjected to drying in a hothouse with forced air circulation at temperatures of 30, 40, 50 and 60 ± 1°C. The samples were placed on removable stainless steel trays with background screen for air flow. The temperature and air relative humidity were monitored through a digital thermo-hygrometer set in the lab. During the drying process, the trays with samples were periodically weighted up to constant mass. A semi-analytical scale was used with precision of ±0.01 g.

Equation 1 was used to estimate the humidity reasons from the *S. platensis* during drying at different temperatures.

$$RX = \frac{X - X_e}{X_i - X_e} \tag{1}$$

where RX is the water ratio within product, dimensionless; X is the water content within product, decimal b.s.; Xi is the initial water content, decimal b.s.; and Xe is the equilibrium water content, decimal b.s.

The mathematical models (Table 1) were set to experimental drying data using Software Statistica 12.0. The statistical estimators of the models were the coefficient of the adjusted determination (R^2), relative error (P) and estimated average error (SE). The values for P and SE were estimated according to Equations 2 and 3.

$$P = \frac{100}{n} \sum_{i=1}^{n} \frac{|Y - Y_0|}{Y} \tag{2}$$

$$SE = \sqrt{\frac{\sum_{i=1}^{n} (Y - Y_0)^2}{GLR}} \tag{3}$$

where Y is the experimental value; Y_0 is the estimated value by the model; n is the number of experimental observations; and GLR is the grade number of liberty of the model.

The selection criterion for statistical estimators was R^2 close to 100%, P < 10%, and SE close to zero (Madamba et al., 1996). The effective diffusion coefficient was obtained through setting of mathematic model of liquid diffusion, depicted by Equation 4, to the experimental data of drying of *S. platensis*. The equation is the analytical solution for the second law of Fick, taking into account the cylindrical geometric shape, disregarding volumetric shrinkage of it (Crank, 1975).

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Table 1. Mathematical models used to predict drying phenomenon of farm products (Kucuk et al., 2014).

Model designation	Model	
RX = a exp (-k t) + (1 - a) exp (-k b t)	Diffusion Approach	(2)
RX = a exp (- k t) + (1 - a) exp (- k a t)	Two Exponential Terms	(3)
RX = a exp(-k t)	Henderson and Pabis	(4)
RX = a exp(-k t) + b exp(-k_0 t) + c exp(-k_1 t)	Henderson and Pabis Modified	(5)
RX = a exp(- kt)+ c	Logarithmic	(6)
RX= a exp(-k t^n)+ b t	Midilli	(7)
RX = exp(- k t)	Newton	(8)
RX = exp(- k t^n)	Page	(9)
RX = exp ((-a-(a^2 + 4 b t)^{0,5})/ 2 b	Thompson	(10)
RX = a exp(-k t) + (1 - a) exp(-k_1 t)	Verma	(11)
RX = 1+ a t + b t^2	Wang and Singh	(12)

RX: Water content ration within product, dimensionless; t: drying time, h; k, ko, k_1: drying constants, h^{-1}; e a, b, c, n: coefficients of the models.
Source: Kucuk et al. (2014)

$$RU = \frac{U - U_e}{U_i - U_e} = 4\sum_{n=1}^{\infty}\frac{1}{\mu_n^2}\exp\left(-\frac{\mu_n^2 \cdot D_{ef} \cdot t}{R_P^2}\right) \quad (4)$$

where D_{ef} is the effective diffusion coefficient, m^2 s^{-1}; μ_n is the equation roots of Bessel at order zero; R_p is the radius of the cylindrical particle, m; t is the time, h; and n is the number of terms.

Eight terms have been used, from which was observed that the value of D_{ef} did not vary. The analytical solution for Equation 5 presents itself in a form of infinite series and, thus, the finite number of terms (n) at the truncation might determines the precision of the results. To evaluate temperature influence in the effective diffusion coefficient, the equation of Arrhenius was used (Equation 5):

$$D_{ef} = D_0 \left(-\frac{E_a}{R\, T_a}\right) \quad (5)$$

where D_o is the pre-exponential factor, m^2 s^{-1}; Ea is the energy activation, kJ mol^{-1}; R is the gas universal constant, 8.314 kJ $kmol^{-1}$ K^{-1}; and Ta is the absolute temperature, K.

Arrhenius' equation coefficients were linearized resulting in Equation 6, with logarithm application as follows:

$$LnD_{ef} = LnD_0 - \frac{E_a}{R} \cdot \frac{1}{T_a} \quad (6)$$

RESULTS AND DISCUSSION

In the process of determining the drying curves for the microalgae *S. platensis*, the initial water content was 83.40±0.2% b.u. (498.77±0.2% b.s), up to the final contents of 6.74, 5.00, 4.76, and 3.58% b.u, for temperatures of 30, 40, 50 and 60°C, respectively.

In Figure 1, the experimental drying values are displayed for the *S. platensis*, performed under various temperature conditions studied.

One can observe in Figure 1, that the necessary time for *S. platensis* to reach constant mass (hygroscopic equilibrium) was 7.00, 4.58, 3.83, and 3.25 h (420, 275, 230, and 195 min) at temperatures of 30, 40, 50, and 60°C, respectively. Reduction in water content was sharper at the beginning of the drying process at temperatures of 40, 50 and 60°C. While for the temperature at 30°C, the water content reduction was slow, increasing drying time.

Sarbartly et al. (2010) obtained drying time of approximately 90 min for the algae, *Eucheuma spinosum in natura* at 60°C, until sample's water content became 30% (b.u.). Faria (2012) observed that necessary time amount for the algae *Kappaphycus alvarezii* to reach water content of 30% (b.u.) was 360, 170 and 100 min at 40, 60 and 90°C temperatures, respectively, taking into account that the drying time can be influenced by room temperature, air relative humidity, species and solely by product type.

As expected, it has been observed that drying rate increased with temperature increase, resulting in an expressive difference amongst all studied temperatures. This behavior is explained by the difference of temperature gradient established between external temperature and inner temperature of the sample. This gradient is the one that rules drying speed in the first decreasing drying rate period.

In Tables 2 and 3, the applied statistical parameters can be found, to compare amongst eleven drying analyzed models, in the various drying conditions for *S. platensis*.

For the four temperatures applied for *S. platensis* drying, it has been observed that in all mathematical models set to experimental data, presented determination coefficient (R^2) close to 1.0 (Tables 2 and 3). According to Madamba et al. (1996), this coefficient alone does not represent a good criterion for the selection of non-linear

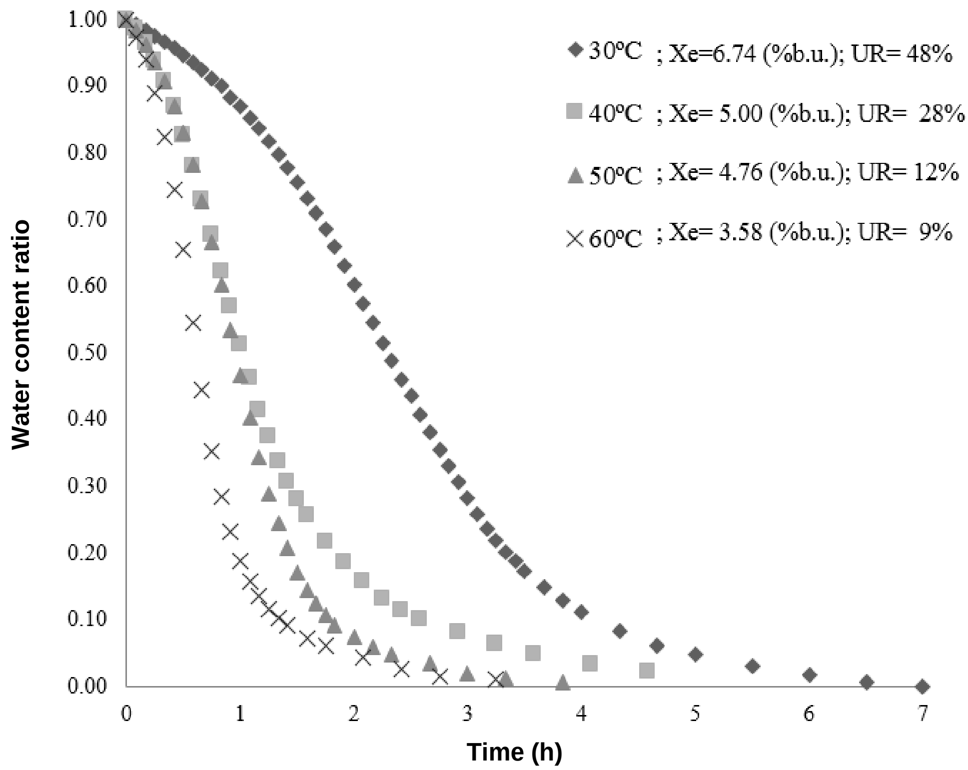

Figure 1. Experimental drying spots for *Spirulina platensis*, at temperatures 30, 40, 50 and 60°C.

Table 2. Determination coefficients (R^2, %), relative error (P,%), average estimated error (SE, decimal) for analyzed models, to the drying of the *Spirulina platensis* at temperatures 30 and 40 ºC.

Model	30°C			40°C		
	R^2 (%)	P	SE	R^2 (%)	P	SE
Diffusion proximity	99.35	22.071	0.039	98.46	20.559	0.064
Two exponential terms	99.14	29.339	0.045	99.89	9.672	0.017
Henderson and Pabis	96.38	66.368	0.091	98.91	13.494	0.053
Henderson and Pabis Modified	99.48	19.222	0.036	99.93	4.961	0.013
Logarithmic	98.00	54.815	0.066	99.08	15.737	0.050
Midilli	99.96	6.331	0.009	99.85	8.327	0.019
Newton	94.07	89.794	0.114	97.88	23.745	0.073
Page	99.92	7.260	0.013	99.76	15.407	0.025
Thompson	94.07	89.786	0.115	97.88	23.739	0.074
Verma	99.35	22.071	0.039	99.89	8.965	0.017
Wang and Singh	97.20	52.786	0.079	98.79	24.522	0.054

models; therefore, the values for estimated average error (SE) and relative average error (P) were disregarded. Many researchers used these statistical parameters to choose the best mathematical model for a given kind of product (Faria et al., 2012; Costa et al., 2015; Corrêa Filho et al., 2015; Martins et al., 2015).

The models which presented the values for statistical parameters according to the selection criterion used were: temperature at 30°C, the mathematic models of Midilli (R^2 = 99.96%; P = 6.331 and SE = 0.009) and Page (R^2 = 99.92%; P= 7.260% and SE=0.013), temperature of 40°C, the models Two Exponential Terms (R^2= 99.89%; P= 9.672% and SE=0.017), Henderson and Pabis modified (R^2 = 99.93%; P=4.961% and SE=0.013),

Table 3. Determination coefficients (R^2, %), relative errors (P, %), estimated average errors (SE, decimal) for analyzed models, for *Spirulina platensis* drying at temperatures 50 and 60°C.

Model	50 ºC			60 ºC		
	R^2 (%)	P	SE	R^2 (%)	P	SE
Diffusion proximity	99.64	12.307	0.033	99.78	9.109	0.026
Two Exponential Terms	99.50	14.573	0.038	99.74	8.520	0.028
Henderson e Pabis	97.31	51.138	0.087	98.06	26.079	0.080
Henderson and Pabis Modified	99.69	11.775	0.032	98.46	18.569	0.071
Logarithmic	97.88	42.773	0.076	98.24	20.906	0.076
Midilli	99.94	9.743	0.013	99.81	12.112	0.024
Newton	95.64	71.737	0.109	96.85	35.707	0.098
Page	99.91	17.126	0.016	99.74	14.824	0.027
Thompson	95.64	71.739	0.111	96.85	35.710	0.101
Verma	99.64	12.307	0.033	97.52	24.744	0.089
Wang and Singh	97.58	73.434	0.079	97.05	29.602	0.077

Midilli (R^2 = 99.85%; P = 8.327 and SE = 0.019) and Verma (R^2= 99.89%; P=8.965% e SE=0.017), temperature at 50°C model of Midilli (R^2 = 99.94%; P = 9.743 and SE = 0.013) was the only one which fit the selection criterion, and temperature of 60°C, mathematical model diffusion proximity (R^2 = 99.78%; P = 9.109%, and SE = 0.026) and Two Exponential Terms (R^2=99.74%; P=8.520% and SE=0.028).

The mathematical model of Midilli is one of the most sensible, presenting fewer coefficient numbers, and making its application and use simpler, for drying simulations (Kashaninejad et al., 2007). However, the mathematical model diffusion proximity is also intensively used, because it holds only three coefficients, which also makes its application simpler. Due to the simplicity of these models, besides being fit for the selection criteria, the model of Midilli was selected for temperatures of 30, 40 and 50°C and diffusion proximity for temperature at 60°C.

In studies with other products, such as gorse (Radünz et al., 2011), the leaves of wolf apple lobo (Prates et al., 2012), basil leaves (Reis et al., 2012), Brazilian peppertree leaves (Goneli et al., 2014b), leaves of Cordia Verbenacea (Goneli et al., 2014a), the model of Midilli were also the one which best fit the experimental drying data. And in other types of products, the model diffusion proximity was also selected for it presented kinetic of drying (Faria et al., 2012).

In Table 4, the mathematical coefficient models are depicted chosen by the selection criterion from the statistical estimators in the modeling of the drying curves for the *Spirulina platensis* at temperatures of 30, 40, 50 and 60°C.

In analyzing the results, one can observe that in the mathematical model of Midilli and the model of diffusion proximity, the drying constant “k” had an increase in its value with the increment of the drying temperature, displaying the influence from coefficient k in relation to the drying temperature. According to Madamba et al. (1996), the drying constant “k” can be used as proximity to characterize the temperature effect and it is linked to the effective diffusivity in the drying process during the decrease period and to liquid diffusion that controls the process. In Equation 7, the set for the drying constant “k” in relation to the drying temperatures at 30, 40, and 50°C was displayed.

$$K = -0.7838 + 0.0325T \qquad (7)$$

R^2= 83.67%

Where K is the drying constant; T is the drying temperature, °C.

In Figure 2, the drying curves are depicted for *S. platensis* with experimental and estimated data by the chosen mathematical model: Midilli for temperatures at 30, 40 and 50°C, and the diffusion proximity model for the temperature at 60°C for time function (h).

In Figure 2, the good adjustment of the model of Midilli for temperatures at 30, 40 and 50°C can be observed and the diffusion proximity model for the temperature at 60°C, once they fit properly the experimental data, reinforcing the applicability of the models for the forecast of the drying data of the *S. platensis*.

Table 5 presented the values of effective diffusion coefficient for the *S. platensis* at studied temperatures, using the radius of the cylindrical particle of 0.001 m.

It is noticeable that with a rise in temperature, the values of the diffusion coefficient increased significantly, as well as displaying the results reported. During the drying of the *S. platensis*, the diffusion coefficient presented magnitude between 3.343×10^{-8} and 14.881×10^{-8} m^2s^{-1}, for temperature range of 30 up to 60°C.

Goneli (2008) explains that when an increase in temperature occurs, the level of vibration in the water

Table 4. Coefficients from the mathematical models chosen by the selection criterion of the statistical estimators set from the drying curve of the *Spirulina platensis*, at studied temperatures.

Model	Coefficients						
	a	b	c	n	k	k_0	k_1
Temperature at 30ºC							
Midilli	1.015	0.007	-	1.542	0.681	-	-
Page	-	-	-	2.083	0.125	-	-
Temperature at 40ºC							
Two exponential terms	2.066	-	-	-	1.244	-	-
Henderson and Pabis modified	24.392	0.143	0.433	-	1.868	-23.555	1.951
Midilli	1.015	0.007	-	1.542	0.681	-	-
Verma	1.866	-	-	-	1.196	-	2.814
Temperature at 50ºC							
Midilli	0.988	0.005	-	2.061	0.757	-	-
Temperature at 60ºC							
Diffusion proximity	59.615	1.021	-	-	3.072	-	-
Two exponential terms	2.181	-	-	-	2.259	-	-

H, k, ko, k_1: Drying constants h^{-1}; e a, b, c, n: coefficients of the models.

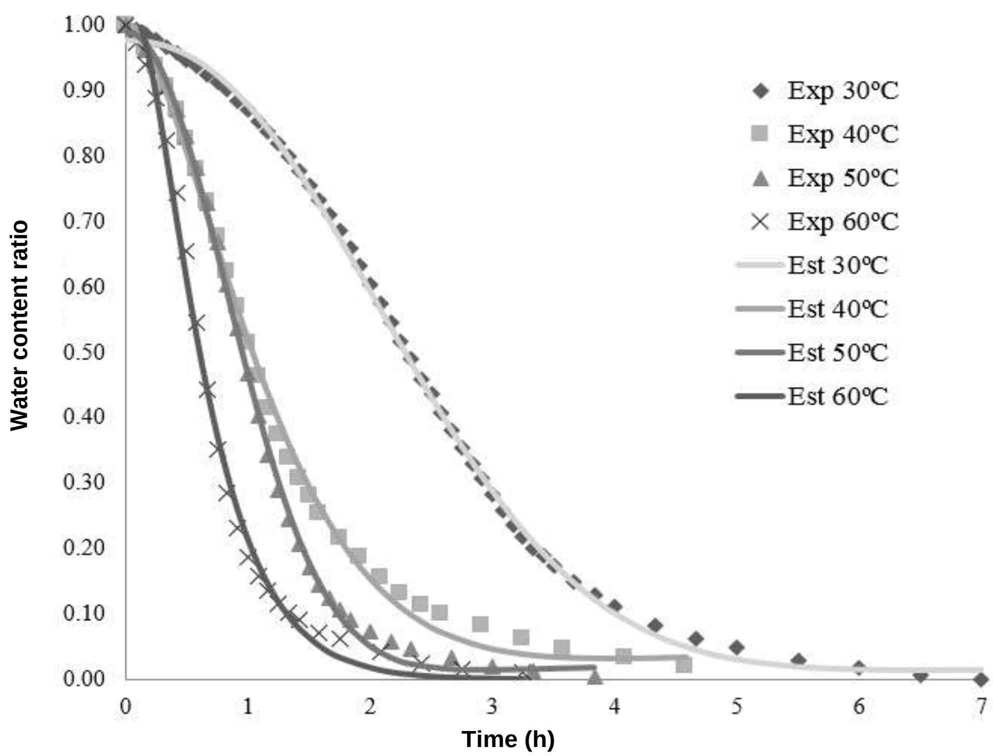

Figure 2. Estimated drying curves (Est) and experimental (Exp) of the *Spirulina platensis*, for temperatures at 30, 40, 50 and 60°C.

molecules also intensifies and its viscosity decreases, which is a measure of fluid resistance to ullage. The variations within this state imply changes in water diffusion into the capillaries of farm products that, alongside with a more intense vibration of water molecules, contribute to a faster diffusion. Therefore, one

Table 5. Effective diffusion coefficient for the *Spirulina platensis* at studied temperatures.

Temperature (°C)	D_{ef} ($\times 10^{-8}$) $m^2 s^{-1}$
30	3.343
40	7.838
50	9.608
60	14.881

Table 6. Effective diffusion coefficients for drying various farm products.

References	D_{ef} (m^2 s^{-1})	Product
Silva et al. (2016)	4.07×10^{-9} and 21.42×10^{-9}	Cabacinha pepper
Martins et al. (2015)	0.66×10^{-11} and 12.07×10^{-11}	Fish stupefying leaves
Rodovalho et al. (2015)	2.67×10^{-12} and 3.33×10^{-12}	Goat pepper seeds
Reis et al. (2015)	1.65×10^{-10} and 5.01×10^{-10}	Little beak pepper
Goneli et al. (2014a)	1.13×10^{-11} and 9.49×10^{-11}	Cordia Verbenacea leaves
Goneli et al. (2014b)	0.15×10^{-11} and 1.58×10^{-11}	Brazilian peppertree leaves

can state that there has been a greater diffusion at 60°C.

According to Rizvi (1995), the effective diffusion coefficient is dependent on the temperature of air used for drying, besides the variety and composition of materials, amongst others; this justifies its increase, with temperature increments of the air used for drying.

In Table 6, the results of the effective diffusion coefficients for drying various farm products are displayed.

Comparing Tables 5 and 6, it is noticeable that the effective diffusion coefficients from the *S. platensis* gathered from the studied temperatures were superior values to the products: cabacinha pepper, fish stupefying leaves, goat pepper seeds, little beak pepper, Cordia Verbenacea leaves and Brazilian peppertree leaves. This can be explained by the chemical constitution of *S. platensis*, which presents weak water link with nutrients, making a higher level of vibration in the water molecules possible, resulting in a reduction in viscosity of the product.

In Equation 8, the linear setting of effective diffusion coefficients is displayed for *S. platensis* in relation to drying temperatures at 30, 40, 50 and 60°C.

$$Def = -7.4546 \times 10^{-8} + 3.638 \times 10^{-9} T \qquad (8)$$

$$R^2 = 96.94\%$$

where D_{ef} is effective diffusion coefficient, m^2 s^{-1}; T is drying temperature, °C.

In Figure 3, the calculated results from D_{ef} are diagrammed, also in the form "ln D_{ef}", described in the mutual function of absolute temperature (1/Ta). The inclination of the curve in Arrhenius' representation delivers the relation Ea/R, whereas its intersection with the Y-axis indicates the value from D_o.

In Figure 3, one can observe that decreasing linearity points out variation uniformity of the drying rate in the studied temperature range.

Equation 9 portrays the coefficient of Arrheinus' equation set for the effective diffusion coefficients of the *S. platensis*, calculated according to Equation 9.

$$D_{ef} = 0.339325.\exp(39{,}520.6/R.Ta) \qquad (9)$$

The activation energy (Ea) for liquid diffusion of the *S. platensis*, calculated as the slope of the obtained line, was 39.52 kJ.mol^{-1}. For Zogzas et al. (1996), the activation energy for farm products ranges from 12.7 to 110 kJ mol^{-1}, and the energy found in this study is according to the value range proposed by those authors.

In Table 7, the results of the activation energy for drying various farm products are displayed. Observing the energy activation values for various products and compared to the gathered value 39.52 kJ mol^{-1} of *S. plantesis,* an activation energy close to adzuki beans and crambe is noticeable. In comparing the chemical constitution, the grains have nutrients existing within the *S. platensis*, gathering values close to the activation energy.

It is highlighted that in the drying processes, the lesser the activation energy, the greater will be water diffusion within the product (Goneli et al., 2014a; Jangam et al., 2010). In other words, the energy needed will be smaller, so that during physical transformation, in this case, occurs the transformation of liquid water into vapor (Corrêa et al., 2010). The activation energy is a barrier that should be broken so that the diffusion process is able

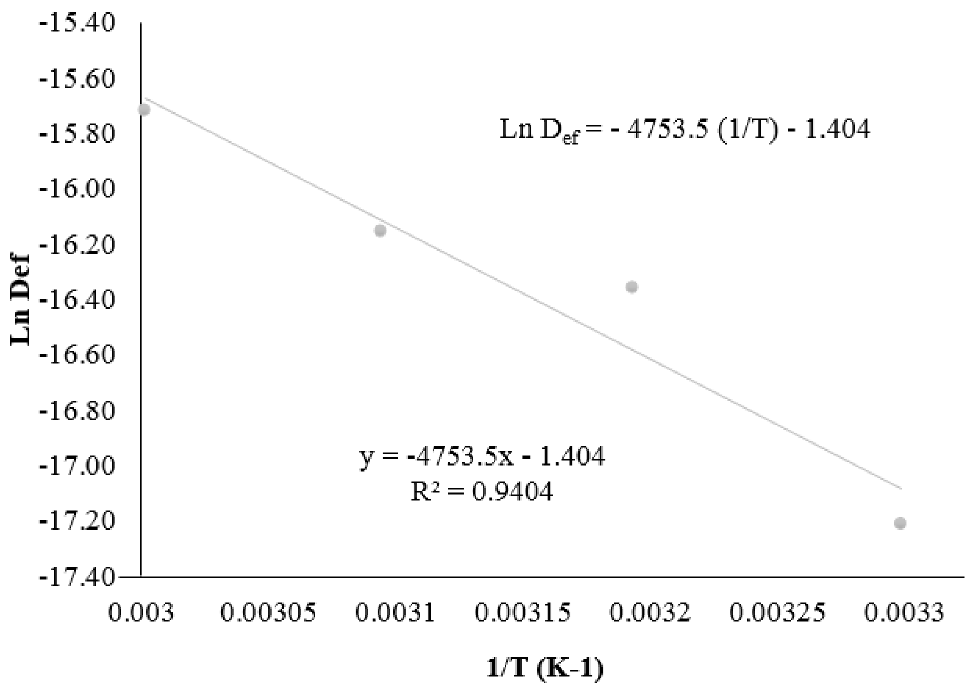

Figure 3. Representation for the effective diffusion coefficient, in relation to air temperature, during the drying of the *Spirulina platensis*.

Table 7. Energy for drying various farm products.

References	E_a (kJ mol^{-1})	Product
Baptestini et al. (2015)	33.10	Soursop foam
Goneli et al. (2014a)	62.89	Cordia Verbenacea leaves
Silva et al. (2014)	34.51	Pigeon pea seeds
Ferreira et al. (2012)	24.512	Fermented grape pomace
Costa et al. (2011),	37.07	crambe
Sousa et al. (2011)	24.78	Turnip feed
Resende et al. (2010)	38.94	Adzuki beans
Martinazzo et al. (2007)	63.47	Lemon grass leaves

to be unleashed in the product (Goneli et al., 2014a; Jangam et al., 2010).

Conclusion

From the results gathered in the study of drying for the *S. platensis* and under the conditions, this work was conducted and one can conclude that:

(1) The amount of time needed for *S. platensis* to reach its constant mass (hygroscopic equilibrium) was 7.00, 4.58, 3.83 and 3.25 h at temperatures at 30, 40, 50 and 60°C, respectively;
(2) The Mathematical model of Midilli at temperatures of 30, 40 and 50°C and the diffusion proximity model at temperature of 60°C are recommended to predict the drying phenomenon of the *S. platensis* for the temperatures studied;
(3) The coefficient of diffusion increased with temperature raise, presenting values ranging from 3.343×10^{-8} to 14.881×10^{-8} m^2 s^{-1}, for temperature range of 30 to 60°C;
(4) The relation between the diffusion coefficient and drying temperature can be described by Arrhenius' equation, which presents activation energy for liquid diffusion of the *S. platensis* of 39.52 kJ.mol^{-1}.

Conflict of Interests

The authors have not declared any conflict of interests.

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