Tropentag, September 20-22, 2017, Bonn

Drying Kinetics of Purple Flesh Sweet potato Grown in Malaysia

M.S. Rosalizan,[1,2] B.Sturm[1], O. Hensel[1], and S.Yahya[2]

[1]Postharvest Technologies and Processing Group, Department of Agricultural & Biosystems Engineering, University of Kassel, Nordbahnhofstr. 1a, 37213 Witzenhausen, Germany

[2] Engineering Research Centre, Malaysian Agriculture Research & Development Institute, 43400 Serdang, Malaysia

INTRODUCTION

Sweet potato is a very important source of carbohydrate for people in Asia. The crop is the fifth most important food crop in developing countries and as such it makes a significant contribution towards their livelihoods. In Malaysia, sweet potato is one of the popular cash crops grown by small farmers and the demand of sweet potato is likely to increase not only for direct fresh consumption but also as a raw ingredient in food processing. Freshly harvested sweet potato is highly perishables and the crop must be consumed within a few weeks after harvest to avoid extensive deterioration. As a result, growers and manufacturers prefer to convert the tubers into more stable forms such as chips and flour by lowering its moisture content through drying. Based on this, there is a need to establish the drying kinetics of purple flesh sweet potato for process optimization and simulation in the future.

OBJECTIVES

To understand the drying kinetics of purple flesh sweet potato grown in Malaysia and to estimate the constants for selected model equations.

MATERIALS & METHOD

Drying experiment

Purple flesh Sweet potato at optimum maturity was harvested at MARDI's farm Kelantan, Malaysia. The crop was sliced at 2 mm thickness and 5.0 ± 0.3 cm diameter prior to drying. Then, the crop was dried at 50°C, 60°C and 70°C until the moisture content reached 0.1 % d.b. The dried crop was packed in the vacuum sealed plastic film for further analyses. Changes in weight of the sample prior to moisture content determination was recorded at 10 mins interval.

Calculation of moisture ratio

Moisture ratio of purple flesh sweet potato during drying was determined according to the equation :
MR = (M-Me)/(Mo-Me)
Where ; M = moisture content at any time t
Mo = initial moisture content
Me = equilibrium moisture content

Mathematical modeling

The mathematical models used in this study are shown in Table 1 .These models were tested for the best fitting of the drying curves of the purple flesh sweet potato based on highest R^2 and lowest λ^2 value.

Calculation of moisture diffusivity

From the equation of MR=(M-Me)/(Mo-Me) = $8/\pi^2 \exp(\pi^2 DT/4L^2)$. A plot of ln MR versus time gives a straight line with slope of $\pi^2 D_{eff}$ / 4 L^2 where L is the half thickness of the slab in meters. The coefficient of diffusivity can be obtained from the slope of the graph.

Calculation of activation energy

$D_{eff} = D_o \exp(Ea / RT)$
Where Ea is the activation energy, R is the universal gas constant of 8.3142 KJ/mol.K and T is the drying temperature in Kelvin.

RESULTS

Table 1: Estimated parameters values and criteria for comparing the mathematical models applied to drying curves of purple flesh sweet potato .

Model	Constant	50°C	60°C	70°C
Wang & Singh (Doymaz, 2005) MR = 1 + at + bt²	a	-0.012429	-0.0141	-0.01534
	b	0.0000403	0.0000496	0.0000341
	R^2	0.991891	0.998541	0.996947
	λ^2	0.002381	0.000239	0.000345
Henderson &Pabis (Mustafa et al., 2009) MR = a exp(-bt)	a	0.981915	1.031841	1.067888
	b	0.016664	0.019655	0.025348
	R^2	0.998679	0.990744	0.972688
	λ^2	0.000236	0.001347	0.003339
Lewis (Fatouh et al., 2006) MR = exp (-at)	a	0.016988	0.019009	0.023689
	R^2	0.998586	0.991898	0.976228
	λ^2	0.000259	0.001374	0.003561
Page (Arabhosseini et al., 2009) MR = exp(-at^b)	a	0.019568	0.007703	0.002584
	b	0.966748	1.22381	1.584136
	R^2	0.998671	0.994841	0.991559
	λ^2	0.00228	0.000667	0.00097
Exponential decay (Cuervo&Hensel, 2008) MR = a + exp(-c (t-b))	a	-0.01174	-0.33161	-1.74655
	b	-0.704009	24.4359	176.3067
	c	0.016102	0.011306	0.005734
	R^2	0.998743	0.998955	0.996854
	λ^2	0.000209	0.000127	0.000336
Diffusion approach (Murthy, 2009) MR = a exp(-kt)+(1-a)exp(-kbt)	a	0.036054	-0.07319	-4.72205
	b	0.031958	0.037118	0.835903
	k	0.511375	0.551337	0.053687
	R^2	0.99893	0.991568	0.988624
	λ^2	0.000187	0.001142	0.001305

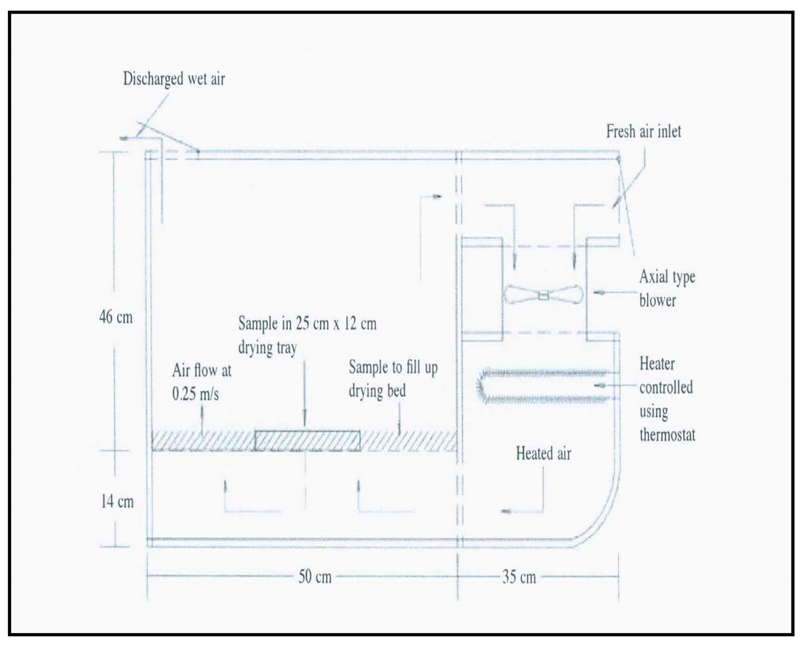

Figure 1: Schematic diagram of the dryer used in this study


Figure 2: Purple flesh sweet potato

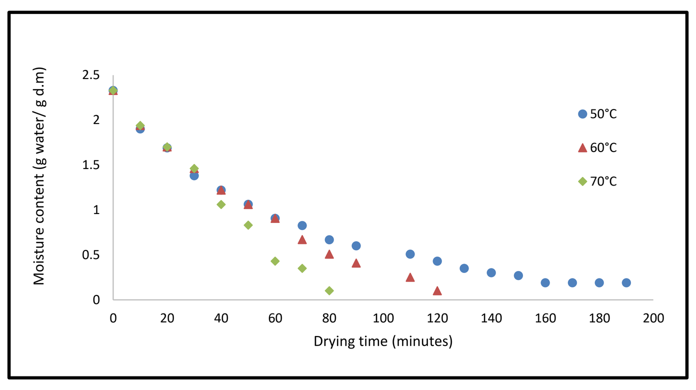
Figure 3: Drying of purple flesh sweet potato at different temperatures.

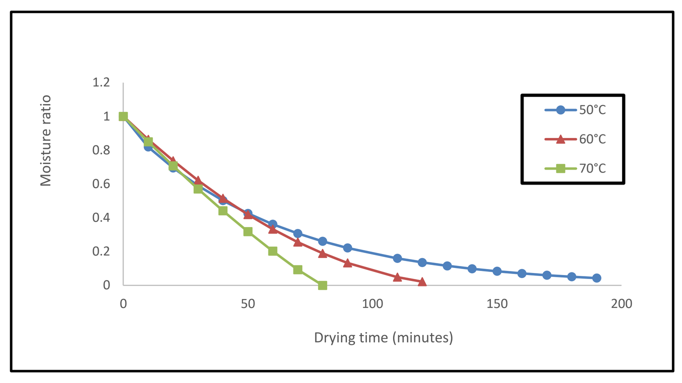
Figure 4: Variation of purple flesh sweet potato moisture ratio with time at different drying temperatures.

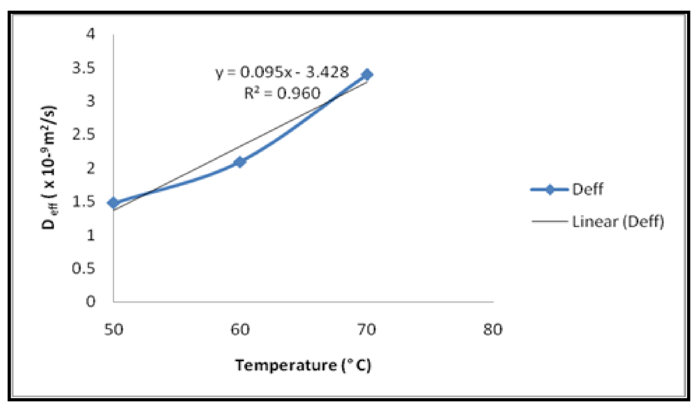

Figure 5: Coefficient of effective diffusivity (m²/s) for the drying of purple flesh sweet potato

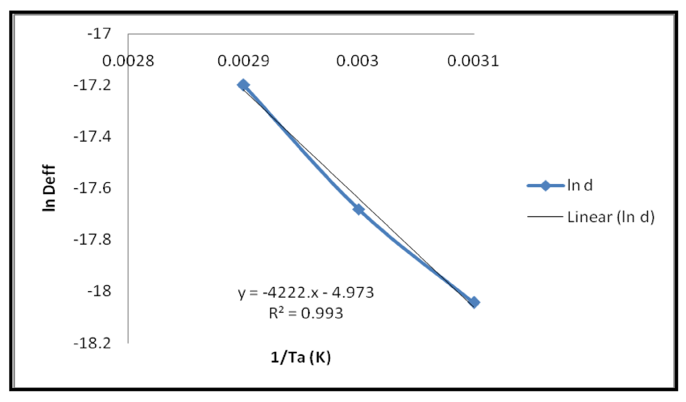

Figure 6: The Arrhenius representation for the coefficient of diffusivity as a function of drying temperature of purple flesh sweet potato

DISCUSSION

- The best model to describe the drying curves for all temperatures is the exponential decay equation with the lowest λ^2 and highest R^2 value as in Table 1. The value of constants in that equation also increased with the increased in temperature.
- The time taken to reduce the moisture content of purple flesh sweet potato from 2.33 % db to a final 0.1 % db was 190, 120 and 70 min at 50°C, 60°C and 70°C respectively.
- Values of effective diffusivity (D_{eff}) were found increased with increased in temperature (Figure 5). Drying at 70°C gave the highest D_{eff} value of 3.3939 x 10^{-9} m^2/s as compared with 50°C and 60°C. The activation energy calculated from this study is 35.102 KJ/mol which is within the range reported by Zogzas et al. (1996) for most of the food materials.

CONCLUSION

The influence of drying temperature at constant air velocity of 0.25 m/s on drying kinetics of Malaysian variety of purple flesh sweet potato was studied for process simulation and optimization. The best fitting model to describe the drying curves of sliced purple flesh sweet potato is exponential decay equation for all drying temperatures. The values of calculated effective diffusivity for drying at 50°C, 60°C and 70°C ranged from 1.46 x 10^{-9} to 3.39 x 10^{-9} m^2/s. The effective diffusivity increased as the temperature increased. The activation energy for moisture diffusion was 35.102 kJ/mol which is comparable with the reported values of various food materials.

REFERENCES

Arabhosseini, O., Padhye, S., Huisman, W., Boxtel, V. and Muller, J. (2209). Food and Bioprocess Technology, 4(7):1281-1287.

Cuervo, S. and Hensel, O. (2008). Proceedings of Tropentag 2008: Conference on International Research on food security, natural resource management and rural development. Stuttgart.

Doymaz, I.(2005). Journal of Food Engineering, 69(2) :161-165.

Fatouh, M., Szumny, A., Gutierrez-Ortiz, A. and Carbonnel-Barrachina, A. (2010). Journal of Food Engineering, 98: 240-247.

Murthy, V. (2009). Renewable and Sustainable Energy Reviews, 13: 835 – 844.

Mustafa, I., Sopian, K. and Daud, R. (2009). Journal of Applied Science, 6(6) : 1070-1075.

Zogzas, N.P., Maroulis, Z.B. and Marinos-Kouris, D. (1996). Drying Technology, 14(10):2225-2253.

ACKNOWLEDGEMENTS

This research was funded by Malaysian Agricultural Research & Development Institute (MARDI) under RMK11 project

Rosalizan Md Saleh
Department of Agricultural and Biosystems Engineering
rosalizan@student.uni-kassel.de