ORIGINAL PAPER

FITTING OF *MYRTUS COMMUNIS L.* DRYING KINETICS CURVES TO MATHEMATICAL MODELS MENTIONED IN THE LITERATURE

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Manuscript received: 01.08.2016; Accepted paper: 12.11.2016;
Published online: 30.06.2017.

Abstract. *This study is aimed at investigating the drying kinetic of Myrtus communis L. leaves by fluidisation at controlled temperatures and air speeds and fitting it to eight mathematical models existing in the literature. Five experiences were carried out for three airflows (Va=1, 0.8 and 0.3 m/s) and three temperatures (40, 50, 60 °C). Fitting of experimental drying curves to the models pointed out that « Modified Henderson and Pabis» model is the most suitable for describing the drying kinetic of this product.*

Keywords: *Model, drying by fluidisation, drying kinetic, Myrtus communis L., fitting.*

1. INTRODUCTION

By its geographical contrast, Morocco offers a varied range of Mediterranean bioclimates with a rich flora of more than 4200 species and varied vegetation, marked by clear endemism. Species with aromatic and/or medicinal interest are estimated as being in the order of 500 to 600 species within which a large number is endemic [1]. This country is a traditional world market supplier of aromatic and medicinal plants. Dozens of products are exported as dried plants for herbalism needs and as flavouring substances. Myrtle is one of the most exploited aromatic and medicinal plants spontaneously produced in Morocco, with an average of 1.5 tons thereof exported between 2001 and 2006. Drying is an essential pre-stocking operation aiming at preserving the quality of stored plants [3]; the humidity percentage of these products should range from 8 to 10%. This is the context of this work whose aim is to study drying kinetic of myrtle leaves by fluidisation at controlled temperatures and air speeds and fitting it to eight mathematical models.

2. EXPERIMENTAL STUDY

2.1 MATERIALS AND METHODS

Drying by fluidisation of myrtle leaves was carried out in well controlled air flow conditions, using a pilot installation for fluidised bed drying (Deltalab-France). This dryer works with electrical energy.

The different experimental conditions of drying are shown in Table 1.

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Table 1. Operational conditions of drying.

Test	Ta (°C)	Va (m/s)	t_s (min)
1	40	1	280
2	50	1	140
3	60	1	100
4	60	0.8	220
5	60	0.3	420

To be able to compare dehydration kinetics of the different leaves samples with various water contents, drying kinetic of myrtle leaves are represented by evolutions of reduced water content (X*) of the product during time. Reduced water content (X*) of the product is calculated using the following formula [4]:

$$X^* = \frac{Xt - Xf}{X0 - Xf}$$

- X_f final water content (kg of water/kg of DM);
- X_0 initial water content (kg of water/kg of DM);
- X_t water content at t instant of drying (kg of water/kg of DM).

2.2 TESTED MODELS

Obtained drying experimental curves are approached by eight mathematical models existing in the literature [5-9] shown in Table 2. These models express reduced water content as a function of time.

Table 2. Drying models existing in the literature.

Model name	Expression of the model
Newton	$X^* = \exp(-a.t)$
Page	$X^* = \exp(-a.t^b)$
Henderson and Pabis	$X^* = a.\exp(-b.t)$
Logarithmic	$X^* = a.\exp(-b.t) + c$
Two term	$X^* = a.\exp(-b.t) + c.\exp(-d.t)$
Two term exponential	$X^* = a.\exp(-b.t) + (1-a).\exp(-b.a.t)$
Wang and Singh	$X^* = 1 + a.t + b.t^2$
Modified Henderson and Pabis	$X^* = a.\exp(-b.t) + c.\exp(-d.t) + e.\exp(-f.t)$

Non-linear modelling has been used in order to obtain the best smoothing equation of drying kinetic of myrtle leaves curves with experimental data. The most suitable model is the one with the highest correlation coefficient value r and the lowest standard error value S.

3. RESULTS AND DISCUSSIONS

3.1 DRYING CURVES

Curves of myrtle leaves drying experimentally obtained, describing the evolution of water content as a function of time, are shown in Fig. 1 and Fig. 2. It suggests that drying is faster as drying air speed and temperature increase [10].

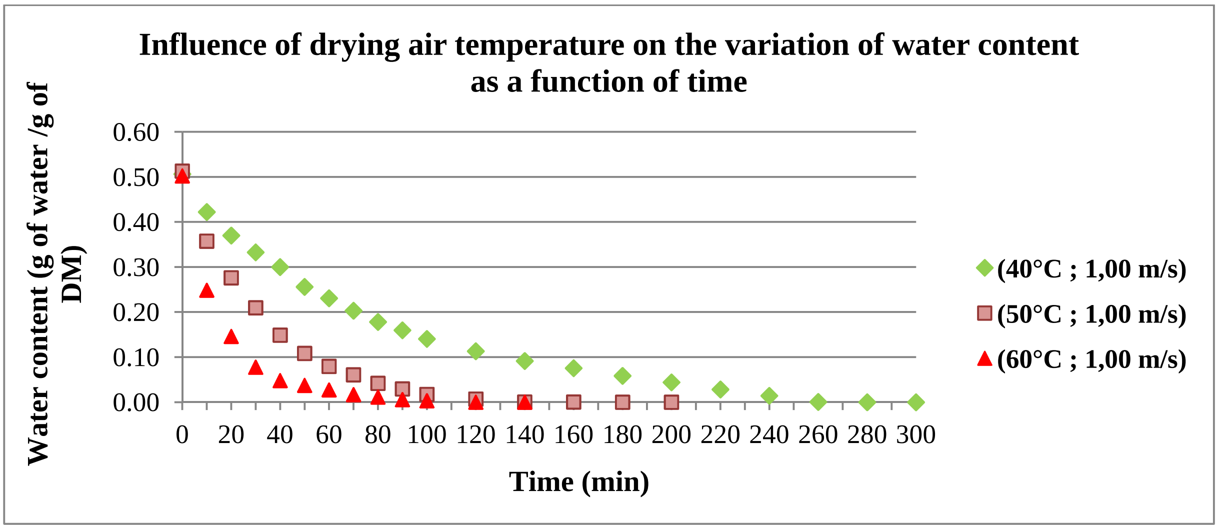

Figure 1. Influence of drying air temperature on myrtle drying kinetic [10].

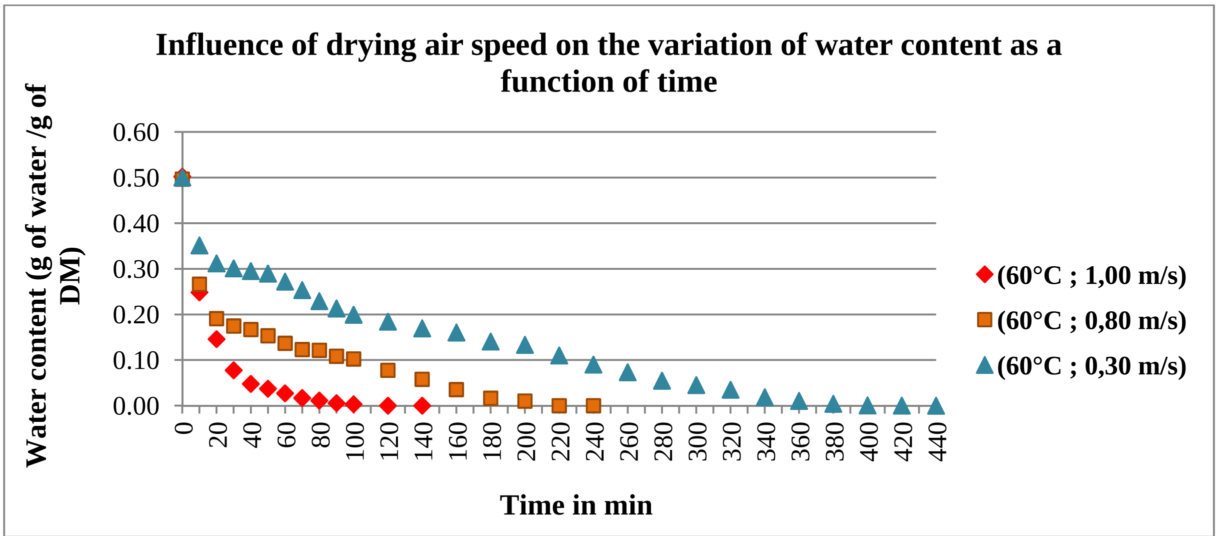

Figure 2. Influence of drying air speed on myrtle drying kinetic [10].

3.2 MODELING OF DRYING KINETIC

Curves describing the variation of reduced water content of myrtle leaves as a function of time are fitted to the eight considered models. Obtained prediction parameters for the five experiments are shown in Table 3.

Table 3. Statistical parameters related to fitting of experimental results to the mentioned models.

Model	Statistical parameters									
	test 1		test 2		test 3		test 4		test 5	
	r	S	r	S	r	S	r	S	r	S
Newton	0.6534	0.2245	0.9991	0.0126	0.9977	0.0201	0.8859	0.1103	0.9471	0.083
Henderson and Pabis	0.7817	0.1898	0.9992	0.0126	0.9978	0.0205	0.9299	0.0903	0.9787	0.0541
Logarithmic	0.9985	0.0173	0.9994	0.012	0.9988	0.0159	0.9415	0.0857	0.9805	0.0529
Two term	0.9983	0.0187	0.9992	0.014	0.9997	0.0086	0.9941	0.0287	0.9787	0.0564
Two term exponential	0.9976	0.0209	0.9992	0.0125	0.9988	0.0154	0.9323	0.0888	0.9507	0.0817
Wang and Singh	0.975	0.0671	0.9732	0.0734	0.8729	0.1508	0.6816	0.1797	0.8885	0.121
Modified Henderson and Pabis	0.9983	0.02	0.9992	0.0158	0.9997	0.0094	0.9941	0.0311	0.9787	0.0591
Page	0.9983	0.0176	0.9992	0.0128	***	***	0.9859	0.0411	0.9772	0.0559

According to regression results, it is noted that the values of correlation coefficients corresponding to three models: Logarithmic, Modified Henderson and Pabis and Two term are the highest, for the curves of drying kinetic related to the five tests carried out. Comparing these models statistical parameters, it appears that « Modified Henderson and Pabis » is the most appropriate model for the adopted operational conditions.

Table 4. Comparaison of the models with highest correlation coefficients.

Model	Correlation Coefficient					
	Test 1	Test 2	Test 3	Test 4	Test 5	Average
Logarithmic	0.9984598	0.999363	0.9988017	0.9414752	0.9804677	0.9837135
Modified Henderson and Pabis	0.9983014	0.999217	0.9997237	0.9940839	0.978692	0.9940036
Two term	0.9983014	0.9992175	0.9996931	0.9940839	0.9786925	0.9939977

Coefficients of the model «Modified Henderson and Pabis» for the different experiments are shown in Table 5.

Table 5. Coefficients of the model «Modified Henderson ad Pabis» for the five carried out experiments.

Drying conditions		**Coefficients of the model**					
Va (m/s)	**Ta (°C)**	**a**	**b**	**c**	**d**	**e**	**f**
1.00	40	3.2276 E-001	1.2590 E-002	3.2276 E-001	1.2590 E-002	3.2276 E-001	1.2590 E-002
1.00	50	3.2975 E-001	3.0700 E-002	3.2975 E-001	3.0704 E-002	3.2972 E-001	3.1540 E-002
1.00	60	6.0006 E-001	8.1400 E-002	3.2931 E-001	3.5005 E-002	7.0842 E-002	1.0723 E+000
0.80	60	2.8038 E-001	1.0805 E-002	2.3176 E-001	1.0804 E-002	4.8856 E-001	2.0120 E-001
0.30	60	2.7405 E-001	6.9157 E-003	2.7405 E-001	6.9131 E-003	2.7405 E-001	7.0683 E-003

Fitting of drying kinetic curves of myrtle leaves (variation of reduced water content as a function of time) to the model « Modified Henderson and Pabis » for considered operational conditions is shown in Figs. 3 – 7.

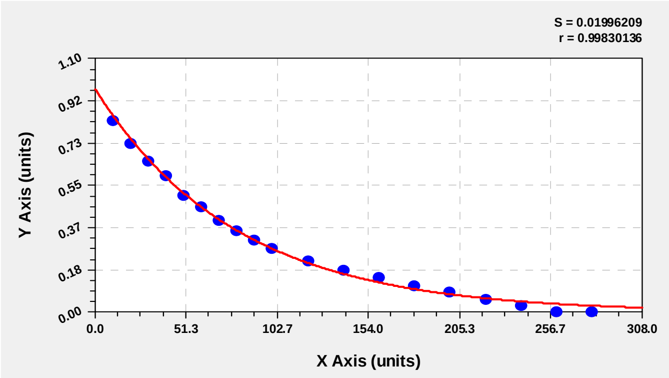

Figure 2. Smoothing of myrtle drying kinetic curve at T=40°C and Va=1m/s by «Modified Henderson and Pabis» model.

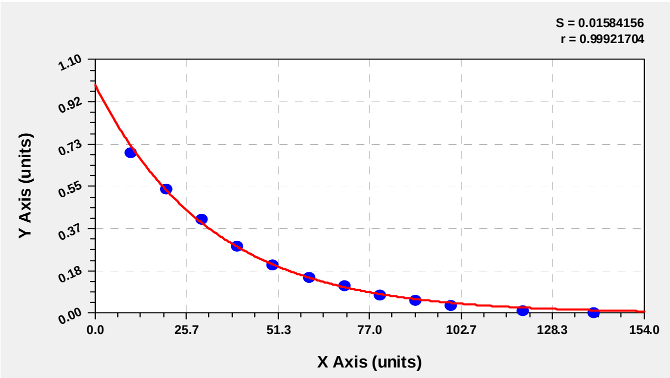

Figure 3. Smoothing of myrtle drying kinetic curve at T=50°C and Va=1m/s according to «Modified Henderson and Pabis» model.

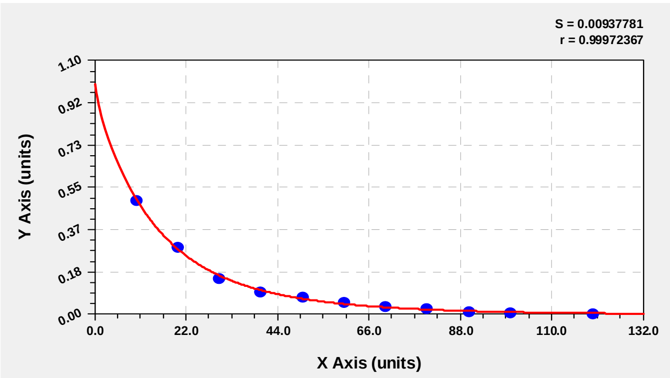

Figure 4. Smoothing of myrtle drying kinetic curve at T=60°C and Va=1m/s according to «Modified Henderson and Pabis» model.

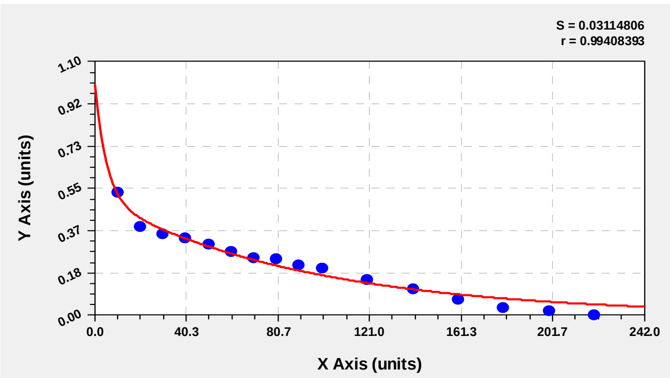

Figure 5. Smoothing of myrtle drying kinetic curve at T=60°C and Va=0.8m/s according to «Modified Henderson and Pabis» model.

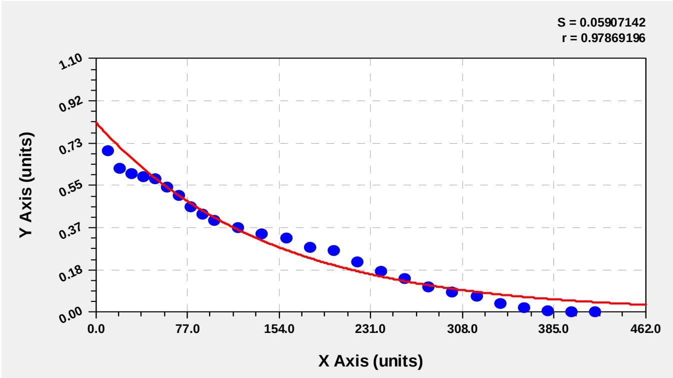

Figure 6. Smoothing of myrtle drying kinetic curve at T=60°C and Va=0.3m/s according to «Modified Henderson and Pabis» model.

4. CONCLUSION

In order to explain myrtle drying behaviour, eight mathematical models were tested. Amongst these models, « Modified Henderson and Pabis » has given the best statistical parameters for various drying experiments carried out in controlled conditions of air speed and temperature. Coefficients of this model were determined for the five experiments.

GLOSSARY

DM: dry matter (g)
r: correlation coefficient
S: standard error
T_a: drying air temperature (K)
t_s: drying time (min)
V_a: air drying speed (m/s)
X*: reduced water content

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