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THIN-LAYER MODELLING AND ANALYSIS OF DRYING CHARACTERISTICS OF CURRY LEAF (*MURRAYA KOENIGII*)

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ABSTRACT:

In this study, the thin layer modelling and analysis of drying characteristics of curry leaves (Murraya koenigii) has been studied in an electric convective dryer with constant air mass flow rate of 0.0636 kg/s and temperatures 50^oC, 60^oC and 70^oC. Twelve thin layer drying models were tested for its suitability to describe the drying characteristics of curry leaves. Based on the statistical parameters, the Modified Henderson and Pabis model was selected for predicting the drying characteristics of curry leaves. This model was seen to have the highest average R-squared and Adjusted R-squared values of 0.9982 and 0.996 respectively, and the lowest average SSE, Chi-squared values and Root – Mean – Square – Error (RMSE) values of 0.005332, 0.0006 and 0.02315 respectively. The moisture diffusivity of samples was evaluated at temperatures of 50 ^oC, and 70^oC respectively. The activation energy was also evaluated to be 82.26KJ/mol. It was observed that the drying rate was faster at 70^0C and gave the best quality of dried curry leave. Further research is needed for the actual commercialization of the locally dried curry leave.

INTRODUCTION

Curry leaves, scientifically known as Murraya koenigii Spreng, belong to the Rutaceae family. The plant is grown in tropical and subtropical regions. It is known to Indian by the name of 'sweet neem'. Curry leaves are natural flavoring agents with a number of health benefits. It makes food both healthy and tasty along with pleasing aroma. Curry leaves have anti-diabetic, antioxidant, antimicrobial, anti-inflammatory, anti-carcinogenic and hepato-protective (capability to protect liver damage) properties, (Gupta S, Prakash J, 2009). The main nutrients found in curry leaves are carbohydrates (18.7gm), energy (108 Kcal), fiber (6.4gm), protein (6.1 gm), fat (1gm), calcium (830mg) and minerals (4 gm). Curry leaves can be used in either fresh or dried form as an ingredient in the food.(http://www.medindia.net/amp/patients/lifestyleandwellness/curry-leaves-health-benefits.html). Drying is a process of moisture removal accompanied by simultaneous heat and mass transfer (Ertekin and Yaldiz, 2015). Though there are many ways in which drying of agricultural produce can be achieved, but the choice of method depends on the material and the hygienic level required. The knowledge of drying behavior of curry leaves is of critical importance for preserving the nutritional and aromatic qualities. The main objective of the present work is to study the effects of drying conditions on the drying behavior of curry leaves.

Removing water from food and agricultural products constitutes a significant portion of the processing activity for persons working in the food and agricultural processing industries (Midilli, A. and Kucuk, H., 2000). Drying also exert great effect on the quality of dehydrated food. Drying simply refers to the removal of water from the tissue structure of food product. The physical, chemical, bio-chemical and microbiological changes which determine nutritional stability are closely connected with the status of water in food product. Drying is a complex thermal process in which unsteady heat and moisture transfer occur simultaneously, which is not easily understandable. The theoretical models may explain heat and mass transfer but it encounters unnecessary computational complexity and time commitment as well as less interpretable (Scalbert, A., Williamson, G. (2000).) The thin-layer modelling and drying analysis is carried out till date. From engineering point of view, the drying process as well as drying parameters plays an important role in thin-layer drying and the quality and acceptability of final dried product. The drying rate is strongly dependent on air velocity, temperature and relative humidity inside dryer. In order to achieve gundruk of better quality and for better process control, effect of these processing parameter on drying process must be identified. Moreover, the drying kinetics of food is a complex phenomenon and requires simple representations to predict the drying behavior and for optimizing the drying parameters (Newman, D. J., Cragg, G. M. (2012). The leaves of this plant has been used widely in indian culinary and the chemical substance which responsible for its aromatic characteristic is P- gurjunene, P- caryophyllene, P- elemene and O-phellandrene2. The presence of β- pinene, β- caryophyllene, β- phellandrene and α- pinene has ability to control the food spoilage either alone or by combination. The author states that the three different morphotypes of Murraya koenigii poses different intensity in its flavor (Anwer et al 1973). The regular type of Murraya koenigii is the fastest growing plant with good looking leaves and with dark green in color. The dwarf type grows as shrub and branches are spread and appears like bushy and the leaves are in light green in color with little taller like regular type and poses its own aroma. The brown type is the most fragrant one (Xie J.T, et al 2006), with thick and smallest leaf structure and in dark brown in color. Previous study has been done widely on curry leave from its stem up to its bark and, thus this review gathers variety of idea from multifarious research which has been done on curry leave and provides a better cognizance of its therapeutic and non-therapeutic properties.

2.0: MATERIALS AND METHODS

These are the procedures followed in the realizing and actualization of the objectives of this research. One of the commonest method of drying is the thermos gravimetric method or oven-dry method in which the sample is dried for a defined period of time at given temperature. It consists of taking sample of approximate, determining its weight, and drying the sample in an oven at the given temperature then weighing the sample and determining the moisture loss. The leaves were bought fresh from a daily market prominently known as Ihiagwa Market at early morning hour of 8:0am clock in Nigerian time. The market is located within same area having a distance of about 10 km from the school premises.

2.1 Method of Data Collection

The leaves are fresh, greenish and without any defect. The sample were stored in a low-density plastic bags. Aluminum foil with a thickness less than 0.2 mm or 0.016 mm was also bought from the same market. The foil is pliable and can be readily bent or wrapped around objects. It was used for the placement of the specimen during the experiment. The weighing processes were done in a short time and the average data of the results were present with less than 5 % range of experimental reproducibility in three decimal places. The moisture content per time of the sample during the process was calculated.

2.2 Experimental Equipment

90l Professional lab vacuum drying oven was used as drying equipment. It’s a blast and constant temperature electricity heating drying oven, which has a digital display and pointer, it is widely used in industrial/agricultural production, scientific research, and medical and health units.

An electronic analytical balance with 0.1 mg readability with a draft shield, was also used in the laboratory for weighing the foil and leaves before and after drying.

A vacuum desiccator made of glass with calcium chloride to absorb water vapor, was used during the experiment to protect and preserve the leaves overnight form moisture. Vernier Caliper was used to note the thickness of the various leaves that was used for the experiment.

Figure1.0 Laboratory drying oven

Model number [DHG-9023A] manufactured by B.Bran scientific and instrument company, England.

This was set at different temperatures as desired for the drying of the leaves at time intervals

Electronic scale weighing machine:

The type used was Adventurer Pro AV313C with S/N 8029311061, manufactured by Ohasus Corporation Pine Book, NJ USA, assembled in USA. This was used for weighing the leaves to obtain the required weight to be dried.

Desiccators: These were used to cool the dried leaves before weighing to obtain the weight at room temperature.

Figure 1.1 Desiccator

2.3 Sampling Procedure

Systematic sampling method was used during the sampling of the leaves. The leaves were selected. Prior to the commencement of the drying experiments, the leaves were destalked from the stem.

The foil was cut into square and rectangular section in the way that it will contain the sample.

The foil was labelled for proper identification and weighed. The thickness of the leaves was noted; 0.50 ± 0.05mm, using the venire caliper. The fresh leaves were uniformly distributed in the foil. The sample was weigh using the weigh balance to a specific weight not less than or more than 15g. The experiment is divided into two parts namely; Initial moisture content determination and drying to equilibrium moisture at different temperatures. The weight of the foil for the placement of the leaves is measured and recorded. 15g of the fresh sample is weighed on using the weighing machine and dried at 80^{0}C for 1hr. The sample is then cooled in the desiccator and weighed, the weight recorded. The same sample is then dried subsequently at 10min intervals until constant weight is obtained. Steps

1 to 4 was repeated for sample B and the average obtained.The initial moisture content of sample on dry weight basis (MC_o) is then computed.

2.4 Drying Procedure

Drying commenced from 10 am to 4pm daily. The experiment is divided into parts-namely; Initial moisture content determination and drying to equilibrium moisture at different temperatures.

Initial moisture content determination. For the initial moisture content determination, the measured samples 15g with precision of the fresh leaves was dried in the oven at 80^{o}C for 1hour. Cooled by placing in the desiccator and the dried sample was weighed. Subsequently, the drying continued at 10mins interval until constant weight was obtained. The same process was repeated on another set of sample.

2.5 Drying at Different Temperatures

The weight of the foil for the placement of the leaves is measured and recorded.

15g of the fresh sample is weighed on using the weighing machine and dried at 50^{0}C for 10mins for the first 30mins and then subsequently for 20mins until a constant weight is obtained.

The sample is cooled in the desiccator and weighed at each time interval, the weight recorded.

Steps 1 to 3 was repeated for sample B and the average obtained. Steps1 to 4 was repeated at 60^{0}C and 70^{0}C for fresh leaves. The moisture ratio (MR) at different time intervals is computed for the different drying temperatures. MR versus time data is plotted and fitted into different thin layer models and the best model determined. The moisture diffusivity and activation energy at different temperatures is also determined and plotted. The moisture ratio of the Utazi leave samples during the drying period was calculated using the following equation.

Where: MR = moisture ratio, Mt = Moisture content at any time (t), Mo = Initial moisture content on dry basis, Me = Equilibrium moisture content. From the experimental results, a graph of MR against T was plotted for each temperature (50^{0}C, 60^{0}C and 70^{0}C) using MATLAB 7.5

The ten drying models used for these analysis are Lewis model, Page model, Modified page model, Logarithmic model, Henderson and Pabis model, Modified Henderson and Pabis Model, Two-term model, Two Term exponential model, Wang Singh model and the Diffusion approach model and statistical parameters such as R-squared, Adjusted R-squared, RMSE, and SSE were used to determine the goodness of the fit of the drying models , thereby determining the best model that describes the drying characteristics of curry.

RESULTS AND DISCUSSION

From the experimental results, a graph of MR against T was plotted for each temperature (50, 60 and 70) using MATLAB 7.5.and fitted to ten models used for the study are Lewis, Page, Henderson and Pabis, Logarithmic, Modified Page, Wang and Singh, Two term, Two term exponential, Modified Henderson and Pabis and Diffusion Approach and the statistical parameters are R- square, Root Mean Square Error (RMSE), Adjusted R^2, SSE and Chi- Square as measures of goodness of fit; to determine the model that best describes the drying kinetics. Goodness of fit results are shown in Tables 4.4 - 4.6.

DISCUSSION

Effect of Drying Temperature on Moisture Content

The effect of drying temperatures (viz. 50 °C, 60°C and 70 °C) on the moisture content of the curry leaves is depicted in Fig.4.1- 4.3. The initial moisture content of the curry leaves was 605.543. The drying rate of curry leaves increased with an increment in the drying temperature from 50 °C to 60°C. It can be inferred that greater the temperature difference between the drying medium and the curry leaves, the greater is the rate of heat transfer into the leaves, which provides the driving force for moisture removal, thus higher drying rate is obtained.

Computation of drying rates

The continuous decrease in moisture content and moisture ratio was noticed with drying time and increase of drying rate with the increase in drying temperature. It is obvious from the drying curves that the constant rate period was absent, and drying of curry leaves took place in the falling rate period for the entire duration. The drying in falling rate period shows that internal mass transfer has occurred by diffusion. The results of statistical analyses which were obtained from a MATLAB 7.5 plot of MR vs Time are summarized in Table (4.1). The best model to describe the drying behaviour of curry leave was selected to be modified Henderson and Pabis.

Model Validation

From the observing the values of the R- square, Adjusted R^2, RMSE, SSE, and Chi- square at average of all the temperature is the modified Henderson and Pabis best describes the drying of characteristics of the drying of curry, since it has the highest value for R^2 and the lowest value for RMSE, SSE and Chi square. From the analysis we obtained the Henderson and Pabis to be the best model so we now obtain the MR Predicted by the model and fit it into a linear model with the MR obtained from the experimental data. A comparison of experimental MR with model predicted in Fig 4.2 - 4.4 shows good agreement.

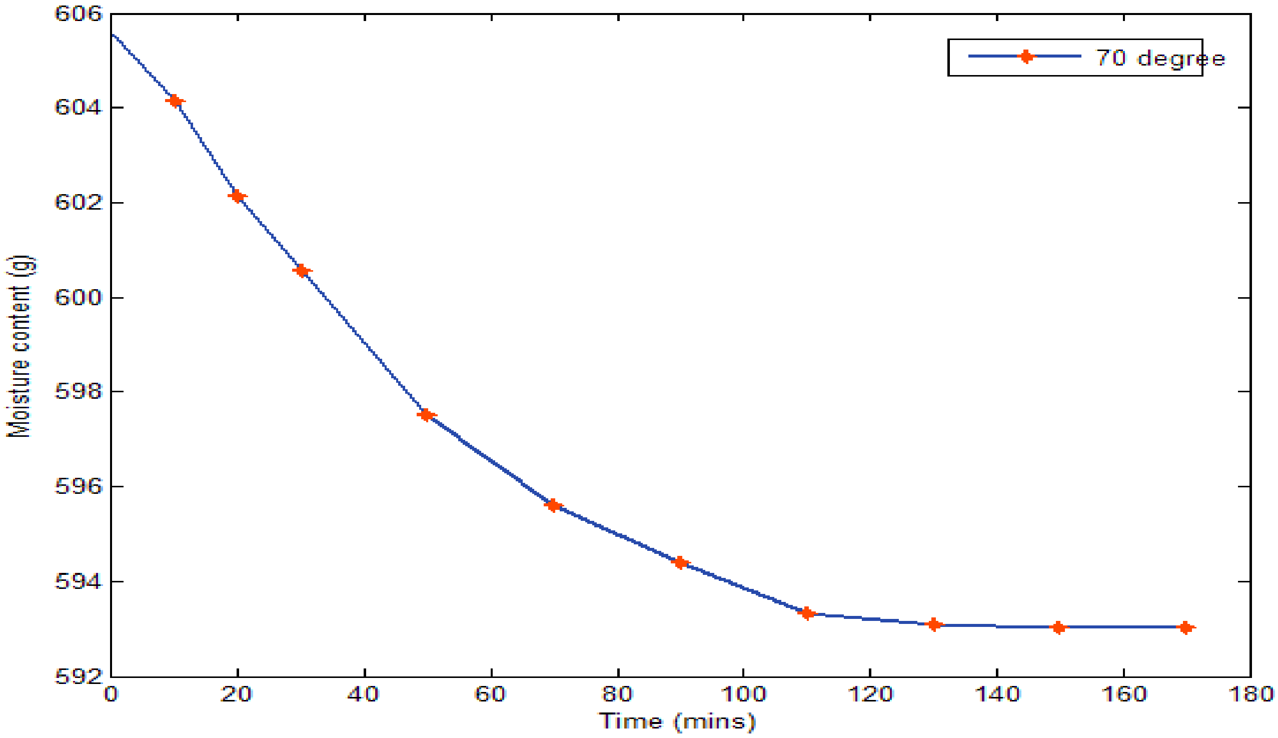
Table 1.0: Result of Drying Characteristics of Curry Leaf at 70°C

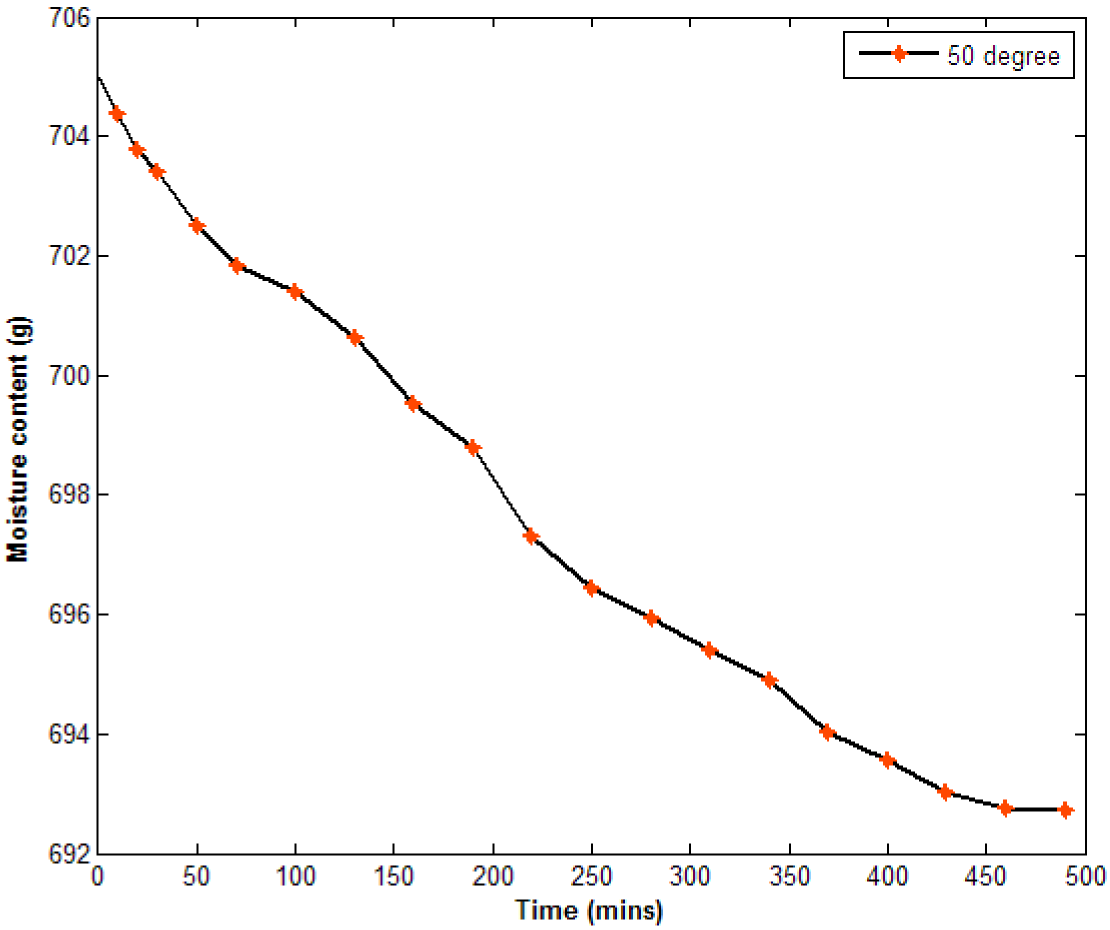
70 degree	sample B		Sample B					
T	**W1**	**W2**	**M**	**Mo**	**Mt**	**Me**	**MR**	**Drying rate**
0.000	15.025	15.025	0.000	605.543	605.543	593.025	1.000	0.00000
10.000	15.025	13.610	1.415	605.543	604.128	593.025	0.887	0.14150
20.000	13.610	11.623	1.987	605.543	602.141	593.025	0.728	0.09935
30.000	11.623	10.027	1.596	605.543	600.545	593.025	0.601	0.05320
50.000	10.027	6.998	3.029	605.543	597.516	593.025	0.359	0.06058
70.000	6.998	5.091	1.907	605.543	595.609	593.025	0.206	0.02724
90.000	5.091	3.863	1.228	605.543	594.381	593.025	0.108	0.01364
110.000	3.863	2.817	1.046	605.543	593.335	593.025	0.025	0.00951
130.000	2.817	2.572	0.245	605.543	593.090	593.025	0.005	0.00188
150.000	2.572	2.509	0.063	605.543	593.027	593.025	0.000	0.00042
170.000	2.509	2.507	0.002	605.543	593.025	593.025	0.000	0.00001

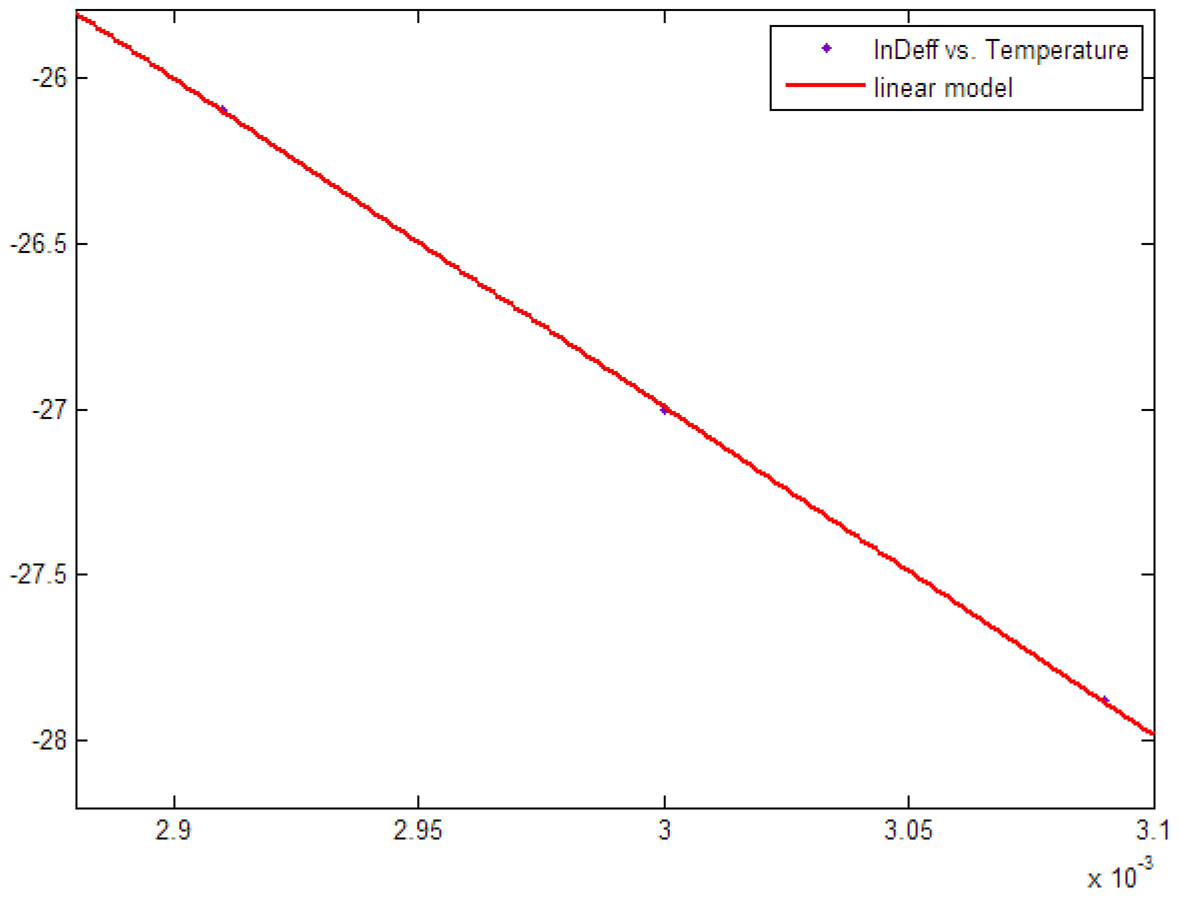
Table 1.1 : Result of Drying Characteristics of Curry Leaf at 50°C

50 degree	SAMPLE A							
T	**W1**	**W2**	**M**	**Mo**	**Mt**	**Me**	**MR**	**Drying rate**
0.000	15.007	15.007	0.000	704.979	704.979	692.710	1.000	0.00000
10.000	15.007	14.411	0.596	704.979	704.383	692.710	0.951	0.05960
20.000	14.411	13.814	0.597	704.979	703.786	692.710	0.903	0.02985
30.000	13.814	13.425	0.389	704.979	703.397	692.710	0.871	0.01297

50.000	13.425	12.544	0.881	704.979	702.516	692.710	0.799	0.01762
70.000	12.544	11.857	0.687	704.979	701.829	692.710	0.743	0.00981
100.000	11.857	11.428	0.429	704.979	701.400	692.710	0.708	0.00429
130.000	11.428	10.642	0.786	704.979	700.614	692.710	0.644	0.00605
160.000	10.642	9.548	1.094	704.979	699.520	692.710	0.555	0.00684
190.000	9.548	8.794	0.754	704.979	698.766	692.710	0.494	0.00397
220.000	8.794	7.320	1.474	704.979	697.292	692.710	0.373	0.00670
250.000	7.320	6.465	0.855	704.979	696.437	692.710	0.304	0.00342
280.000	6.465	5.980	0.485	704.979	695.952	692.710	0.264	0.00173
310.000	5.980	5.424	0.556	704.979	695.396	692.710	0.219	0.00179
340.000	5.424	4.911	0.513	704.979	694.883	692.710	0.177	0.00151
370.000	4.911	4.069	0.842	704.979	694.041	692.710	0.108	0.00228
400.000	4.069	3.580	0.489	704.979	693.552	692.710	0.069	0.00122
430.000	3.580	3.056	0.524	704.979	693.028	692.710	0.026	0.00122
460.000	3.056	2.773	0.283	704.979	692.745	692.710	0.003	0.00062
490.000	2.773	2.738	0.035	704.979	692.710	692.710	0.000	0.00007


70 degree
Moisture content (g)
Time (mins)
606
604
602
600
598
596
594
592
0
20
40
60
80
100
120
140
160
180


50 degree
Moisture content (g)
Time (mins)
706
704
702
700
698
696
694
692
0
50
100
150
200
250
300
350
400
450
500



5.0 CONCLUSION

The Leaf sample (Curry) was dried at varied temperatures 50 and 70°C Simultaneously using three Curry Samples. The three samples were dried till they all attained equilibrium moisture content. It was Observed from the experiment that the drying of the Curry followed falling rate period of drying. Moisture ratio was computed using the moisture content data of the samples obtained at different time intervals at different drying temperature. Modified Henderson and Pabis Model showed better fit with highest correlation coefficient R^2 and lowest SSE values during process of the curry leaves. Effects of hot air temperature on the drying time were investigated for curry leaves. The time required for drying of curry leaves at 50°C and 70°C and air velocity of 1 ms-1 was 490 and 170 min respectively for hot air tray dryer. The drying rate was higher when the drying was carried out at 70°C as compared with drying performed at 50°C.The highest temperature during the experiment was 70 degrees, and it gave the best quality of dried curry leaves, which showed a better physical effects on colour and shrinkage level.

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