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Mathematical modeling evaluation for convective hot air drying of poultry meat

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■ **ABSTRACT :** The aim of this study is to determine drying behaviour of different two type chicken meat samples at five temperatures (45, 55, 65, 75 and 85 °C), five air velocities (2.5, 3.5, 4.5, 5.5 and 6.5 m/s) and three thicknesses (1 cm^3, 1.5cm^3 and 2 cm^3) in high velocity hot air dryer for manufacturing of dried chicken meat product. Only falling-rate period was observed for both of the dried meat samples. The five empirical models namely page's, Logarithmic, Exponential, two term exponential and Henderson and Pabis were fitted to experimental moisture ratio data. These models were tested in MATLAB software version R2013a using curve-fitting tool box with nonlinear method of Levenberg-Marquartd algorithm. Performance of five drying models was evaluated on the basis of co-efficient of determination (R^2), standard error estimation (SEE) and root mean square error (RMSE)by using nonlinear regression analysis. Page's model gave better prediction for moisture ratio.

■ **KEY WORDS :** Mathematical modelling, Meat drying, Poultry meat, MATLAB

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Meat drying offers advantages not only as a way of preservation however additionally helps to reduce packaging and transportation cost by reducing the load and volume. Currently, dried meat product are often simply incorporated in food formulations and through preparation; as an example, dried meat cubes in instant noodle cup. Additionally to sun drying, numerous technologies are often used to manufacture dried meats, like hot air drying, freeze drying, superheated steam drying and microwave-assisted freeze drying (Clemente *et al.*,2009 and Sa-adcom *et al*., 2011) Meat Drying is to reduce the water content so microbes are unable to survive (Shawkat, 2008). Hot air drying is taken into account as a relatively easy, economical and efficient technique to increase the shelf-life of chicken meat. The effectiveness of a drying method depends on totally different factors: method of heat transfer, continuity or discontinuity of the process, direction of the heating fluids with regard to the product. Drying methods are often performed by using totally different type of equipment such as: air cabinet, belt drier, tunnel drier, fluidized bed, spray drier, drum dryer, foam dryer and freeze-dryer. Therefore, meat drying may be used as preservation method to make dried meat product shelf stable. Using high velocity hot air dryer to remove most of the water present in meat by evaporation. Consequently, the water activity (aw) is lowered thereby retarding the microbial growth and also stop the biochemical reactions. The dried meat product may thus have a longer shelf-life. Dried meat products form an important component in the diet of many people. Some of them are even considered as specialty items in many countries. The reasons for drying are virtually as diverse as the dried materials. Generally drying is applied for economic reasons or to ease handling. Moisture content of the many materials should be reduced to a prescribed value before being sold-out. Foods are dried typically for preservation purposes.

Meat preservation of raw meats is difficult for the reason that they are very perishable in nature. Drying is commonly used for the safeguarding of meat to achieve some traditional created dried meat products. The information provided are essential to control the drying operations and for a decent modeling of kinetics for hot air drying of chicken. Good knowledge and drying kinetics modeling, in conditions and actual processes, are elementary requirements to accomplish suitable modeling and drying processes design. The drying curves of chicken of treated chicken meat samples and raw chicken meat samples dried with different three level of size at five level of temperature and five level of air velocity in high velocity hot air dryer were fitted to five drying mathematical models. The five different mathematical models were fitted to investigational data for choosing the best model. These models were tested in MATLAB software version R2013a using curve-fitting tool box with nonlinear method of Levenberg-Marquartd algorithm. For the tested models, the goodness of fit was evaluated using regression analysis.

■ METHODOLOGY

Sample preparation :

At time of samples preparation, the skin of chicken breast meat was removed first and the flesh was then cut normal to the muscle fibers into three sample sizes of 1x1x1cm, 1.5x1.5x1.5cm, 2x2x2 cmusing a sharp knife.

Pretreatment of chicken meat sample :

The chicken meat samples of three different dimensions were pretreated with a solution containing 3.5 per cent of sodium chloride only (raw sample) and other which were treated with solution of 3.5 per cent of sodium chloride plus 0.015 per cent of sodium nitrite. The chicken meat samples for both pretreatments were dipping into solutions at 50°C for 10 minutes. The ratio of chicken meat to solution was 1:2 w/v (Choi *et al.*, 2008 and Comaposada *et al.*, 2000). After pretreatment, the chicken meat samples were removed from solution and spread on a screen to drain off the excess water. Pretreatment was carried out to avoid microbial growth and undesirable quality changes during hot air drying and storage period.

Hot air drying experiment :

In this study, the drying experiments were accompanied at temperature of 45, 55, 65, 75 and 85° C and air velocity of 4.5, 5.5 and 6.5 m/s for meat size of 1.0×1.0 ×1.0 cm, 1.5×1.5× 1.5 cm and 2.0× 2.0× 2.0 cm with three replication each. High velocity hot air dryer was used for drying of chicken meat samples. In High velocity hot air dryer, the prepared samples were taken about 1 kg and equally spread on circular aluminum tray (size 460 mm diameter) and dried by radial diffusion. At the time of drying process, moisture loss was recorded in every 10 min intervals using a digital balance with accuracy of ±0.001 g (Metteler, Germany).

Moisture content (MC) :

The following method suggested by Ranganna (1986) and IS-4626:1968 was used to determine the moisture content.In a flat bottom metallic dish, the powder of asbestos in form of thin layer was spread and dried in a hot oven under temperature of 110°C for time of an hour. It was speedily enclosed and cooled in a desiccator and weighed (W_1). The sample of chicken meat was placed on thin layer of the asbestos and weighed as speedily as possible to avoid loss of moisture (W_2). The cover was detached and the samples of chicken meat were placed in hot air oven under temperature of 102±1°C. The samples of chicken meat were dehydrated till two to three successive weights did not differ more than 5mg and final weight was noted (W_3). Now, moisture content was measured using the following formula:

$$\text{Moisture content, \% (d.b.)} = \frac{[(W_2 - W_1) - (W_3 - W_1)]}{(W_3 - W_1)} \times 100$$

Moisture ratio (MR) :

Moisture ratio was calculated using following equation and it could be defined as it is a ratio of average moisture content at given time to equilibrium moisture content and moisture content initially at zero time to equilibrium moisture content. Moisture ratio was

Table A : Mathematical models used for describing drying of chicken meat

Model No.	Model name	Model expression
1.	Two term exponential model	MR = a x exp (-bt) + (1 – a) exp (-b x a x t)
2.	Henderson and Pabis model	MR = aexp (-kt)
3.	Logarithmic model	MR= a + exp(-bt) +c
4.	Exponential model	$MR=e^{-Kt}$
5.	Page model	$MR=\exp(-kt^{n})$

Where, t is time, minutes.
k and n are drying constants, a,b and c are model constants

dimensionless quantity.

$$MR = \frac{M - M_e}{M_0 - M_e} \tag{2}$$

where, M= Average moisture content at time t, (%db)

M_e= Equilibrium moisture content (%db)

M_0= Moisture content (%db)at zero time.

Mathematical modeling :

For designing the different types of dryers and selecting drying conditions, there is need to develop mathematically models to predict moisture content and drying rate. Generally drying behaviour could be seen graphically. Numerous efforts have been made to develop empirical mathematical models. The moisture content curve could not explain drying behaviour better than that of moisture ratio curve. The moisture ratio curve could be descried drying behaviour with good result as compared to moisture content curve. Moisture ratio curve was used for describing drying behaviour in many researchers relate to thin drying. In present study, the obtained moisture ratio data were fitted into five mathematical models namely page's model, logarithmic model, exponential model, two term exponential model, and Henderson and Pabis model to select the best mathematical model based on best predicted results. These five models in mathematical expressions are given in Table A.

Statistical analysis :

Five drying models were fitted in the experimental data and performance of these models was evaluated on the basis of co-efficient of determination (R^2), standard error estimation (SEE) and root mean square error (RMSE) showed best fit (Doymaz, 2008; Vidakovic, 2011 and Usub *et al.*,2010). All five drying models were tested on MATLAB software 2013 using curve fitting tool box with nonlinear regression method of levenberge-Marquart algorithm (Samira *et al*., 2016).

$$R^2 = 1 - \frac{\sum_{i=1}^{N}(X_{Predicted,i} - X_{Experimental,i})^2}{\sum_{i=1}^{N}(X_{Predicted,i}) - \bar{X})^2} \tag{3}$$

$$RMSE = \left[\frac{1}{n}\sum_{i=1}^{N}(X_{Predicated,i} - X_{Experimental,i})^2\right]^{1/2} \tag{4}$$

where $X_{Predicted,i}$ is the network (predicted) output from observations, $X_{Experimental,i}$ is the experimental output from observation, $\bar{X}$ is the average value experimental output, and N is the total number of data observations in each setup.

■ RESULTS AND DISCUSSION

The drying behaviour was characterized by plotting versus drying time. The graphs for moisture ratio is given in Fig.1. These figures shows that moisture ratio decreased exponentially with time. It was observed that there was rapid decreased in moisture ratio with faster rate in thirty minutes during drying of raw chicken meat samples and treated meat samples, however in later stage of drying, moisture ratio decreased with slower rate. These graphs also presented the exponential drying curves that indicates the change in moisture ratio with drying time at sample size of 1, 1.5 and 2 cm thickness for treated chicken meat samples and raw chicken meat samples. All the drying curves in graphs indicated moisture ratio value at zero time was 1 and after that moisture ratio value with successive drying time was reduced. The drying curves of all graphs showed that the decreased in moisture ratio with time was none linearly on continuous drying time interval which were dependent on drying variables. Outcomes of drying showed that time required to reduce the moisture content within the safe rage was mainly pretentious by different air temperature level. Thus, the these curves can superior define the effect of air temperature, size of samples and

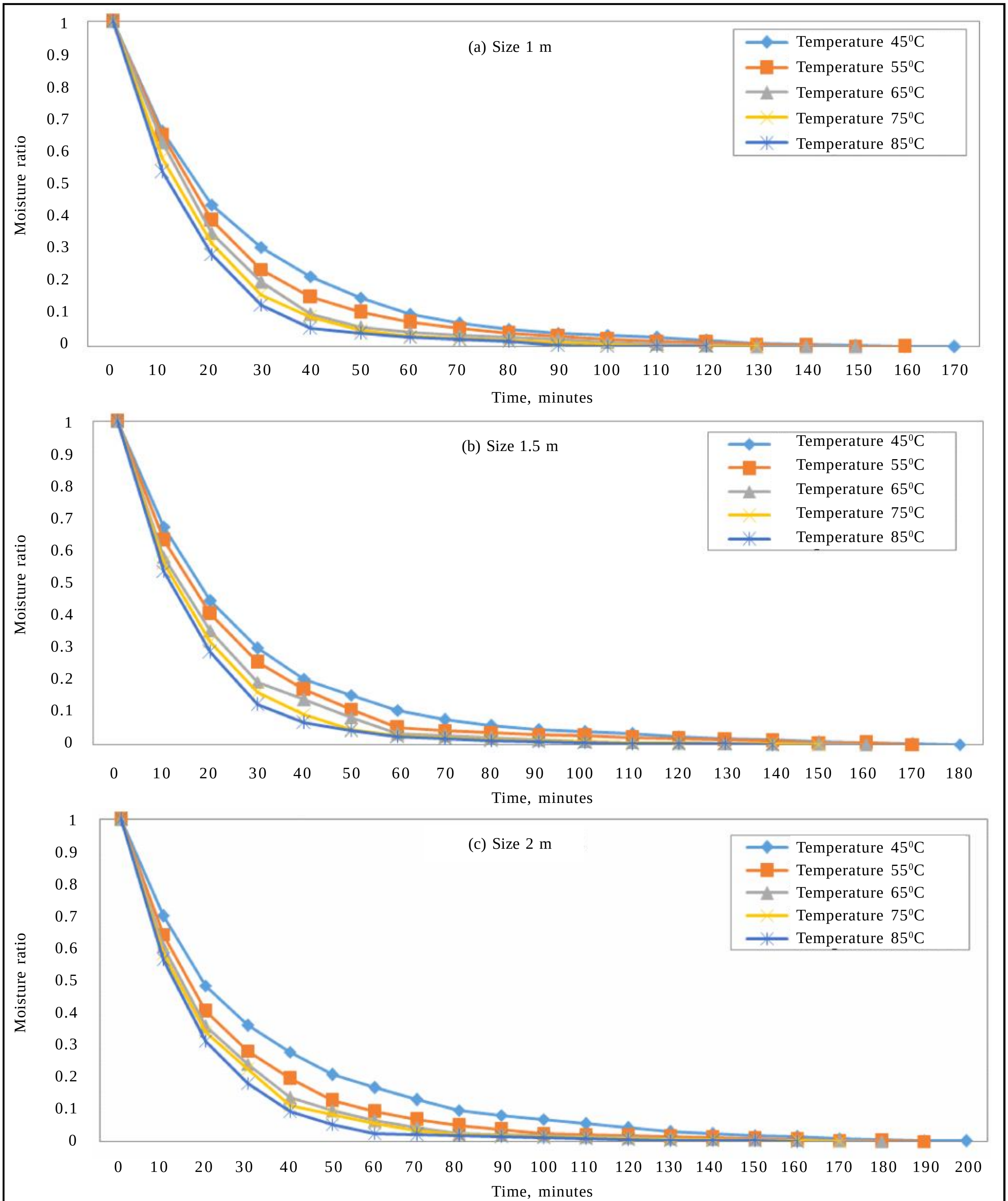

Fig. 1 : Changes in moisture ratio with drying time for meat samples at different temperatures

air velocity flow on drying of chicken meats as compared to moisture curves because of different samples had different moisture content.

Mathematical modeling :

The observed results of moisture ratio with different drying conditions were fit for five drying models such as Page, Henderson and Pabis, Logarithmic, exponential, and two terms exponential for stating drying characteristics of chicken meat cubes dried by high velocity hot air dryer. The moisture content of chicken samples were converted into moisture ratio to accomplish modeling studies of hot air drying.

Table 1 shows the maximum and minimum value of R^2, SEE and RMSE for different five mathematical models for treated and raw chicken meat samples. The moisture ratios obtained from moisture content were fitted to five mathematical models. These five models were fitted to observed data and achieved drying constants, R^2, SEE and RMSE. The Models constants that are given in the tables, can be support the investigators to predict the drying behaviour of a comparable food product without doing any investigational studies. The five mathematical models namely, page's model, logarithmic model, exponential model, Two-term exponential Model and Henderson and Pabis Model were used to predict the drying curve of chicken meat drying during high velocity hot air drying. The root mean square error (RMSE), standard error of estimate (SEE) and the co-efficient of determination (R^2) statistics were used to evaluate the exactness of fit (Sheskin, 2004). The co-efficient of determination (R^2) was main criteria for deciding the best model to define the drying curves. Other than R^2, the root mean square errors (RMSE) was used to decide the goodness of fit. For best fit, co-efficient of determination (R^2) value should be higher and root mean square errors should be lower (Khazaei *et al.*,2007; Roberts *et al.*, 2008 and Vega Galvez *et al.*, 2008).

Page's model and two-term exponential Model had good correlations with experimental data of hot air drying for all treatments. But as compare to Page's model and Two-term exponential Model, the Exponential Model, Logthemic Model and Henderson and Pabis Model had low correlation with experimental drying data for treated and raw chicken meat samples. However, according to selection criteria for mathematical model, the maximum value of R^2, with minimum value of SEE and RMSE were obtained for the Page's model and Two-term exponential Model model. These models are very successful for describing drying kinetics of numerous agricultural and food products (Cakmak *et al.*, 2013 and Tulek, 2011).

The values of co-efficient of determination (R^2) for page's model was highest as 0.9999 whereas the lowest value of R^2 was 09941 in all treated samples drying. In addition to raw samples drying the maximum and minimum values of R^2 were 0.9907 and 0.9850, respectively. The value of R^2 for Two-term exponential Model was 0.9998 in drying of treated chicken meat samples but minimum value of R^2 was 0.9918 in drying of treated chicken meat samples. In case of raw samples drying, the lowest and highest values of R^2 for Two-term exponential Model were 0.9834 and 0.9918. From Table 1, it was found that the maximum values of determination of co-efficient for exponential Model, Henderson and Pabis Model, and Logthemic Model were 0.9997, 0.9996 and 0.99970, respectively in treated samples drying while the minimum values of

Table 1 : Maximum and Minimum value of R^2, SEE and RMSE for different five mathematical models

Model	Type of sample	R^2		SEE		RMSE	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Page's model	Treated sample	0.9999	0.9941	0.00944	0.0001413	0.02121	0.00101
	Raw sample	0.9907	0.9850	0.01040	0.00020	0.02180	0.00100
Exponential model	Treated sample	0.9997	0.9713	0.03248	0.00026	0.04935	0.00134
	Raw sample	0.9897	0.9615	0.03572	0.00029	0.05379	0.00146
Logthemic model	Treated sample	0.9997	0.9814	0.02086	0.00025	0.03826	0.00174
	Raw sample	0.9887	0.9706	0.02294	0.00028	0.04208	0.00191
Henderson and Pabis	Treated sample	0.9996	0.9771	0.02528	0.00026	0.04105	0.00542
model	Raw sample	0.9917	0.9692	0.02806	0.00029	0.04556	0.00602
Two-term exponential	Treated sample	0.9998	0.9913	0.00960	0.00020	0.02530	0.00120
model	Raw sample	0.9918	0.9834	0.01140	0.00020	0.03040	0.00150

Table 2 : Page's model statistic and constants for drying of treated chicken meat samples

Air velocity(m/s)	Size(cm^3)	Temperature	R^2	SEE	RMSE	k	n
2.5	1	45	0.9993	0.0009	0.0071	0.0478	0.9111
2.5	1	55	0.9992	0.0010	0.0080	0.0534	0.9208
2.5	1	65	0.9976	0.0028	0.0136	0.0599	0.9240
2.5	1	75	0.9977	0.0026	0.0135	0.0550	1.0050
2.5	1	85	0.9978	0.0024	0.0136	0.0505	1.0630
3.5	1	45	0.9993	0.0008	0.0075	0.0542	0.8997
3.5	1	55	0.9999	0.0001	0.0032	0.0582	0.9099
3.5	1	65	0.9991	0.0010	0.0087	0.0705	0.9029
3.5	1	75	0.9989	0.0012	0.0099	0.0669	0.9435
3.5	1	85	0.9989	0.0011	0.0101	0.0787	0.9152
4.5	1	45	0.9995	0.0006	0.0069	0.0570	0.9060
4.5	1	55	0.9987	0.0013	0.0106	0.0661	0.9096
4.5	1	65	0.9987	0.0013	0.0111	0.0564	0.9957
4.5	1	75	0.9993	0.0007	0.0083	0.0624	0.9896
4.5	1	85	0.9991	0.0009	0.0098	0.0618	1.0150
5.5	1	45	0.9994	0.0007	0.0076	0.0449	0.9985
5.5	1	55	0.9992	0.0009	0.0088	0.0534	0.9851
5.5	1	65	0.9996	0.0005	0.0068	0.0600	0.9859
5.5	1	75	0.9998	0.0002	0.0050	0.0550	1.0210
5.5	1	85	0.9992	0.0007	0.0095	0.0637	1.0320
6.5	1	45	0.9989	0.0013	0.0103	0.0379	1.0740
6.5	1	55	0.9993	0.0007	0.0082	0.0486	1.0470
6.5	1	65	0.9991	0.0009	0.0095	0.0552	1.0370
6.5	1	75	0.9990	0.0010	0.0106	0.0576	1.0610
6.5	1	85	0.9991	0.0008	0.0102	0.0528	1.1250
2.5	1.5	45	0.9991	0.0013	0.0086	0.0499	0.9488
2.5	1.5	55	0.9986	0.0019	0.0106	0.0390	0.9684
2.5	1.5	65	0.9991	0.0011	0.0083	0.0491	0.9406
2.5	1.5	75	0.9989	0.0013	0.0094	0.0553	0.9615
2.5	1.5	85	0.9986	0.0016	0.0106	0.0528	1.0010
3.5	1.5	45	0.9988	0.0015	0.0095	0.0618	0.8153
3.5	1.5	55	0.9987	0.0015	0.0099	0.0788	0.7773
3.5	1.5	65	0.9985	0.0017	0.0110	0.0892	0.7796
3.5	1.5	75	0.9990	0.0088	0.0010	0.0924	0.7989
3.5	1.5	85	0.9992	0.0008	0.0083	0.0816	0.8741
4.5	1.5	45	0.9992	0.0010	0.0080	0.0462	0.9448
4.5	1.5	55	0.9981	0.0023	0.0129	0.0451	0.9892
4.5	1.5	65	0.9987	0.0015	0.0106	0.0527	0.9878
4.5	1.5	75	0.9987	0.0014	0.0107	0.0551	1.0100
4.5	1.5	85	0.9988	0.0013	0.0108	0.0611	1.0030
5.5	1.5	45	0.9992	0.0009	0.0085	0.0618	0.8627
5.5	1.5	55	0.9991	0.0010	0.0092	0.0621	0.8877
5.5	1.5	65	0.9984	0.0016	0.0122	0.0790	0.8546
5.5	1.5	75	0.9989	0.0011	0.0103	0.0853	0.8540
5.5	1.5	85	0.9993	0.0006	0.0083	0.0845	0.8790

Table 2 contd…

Table 2 contd…

6.5	1.5	45	0.9982	0.0020	0.0125	0.0550	0.9368
6.5	1.5	55	0.9995	0.0005	0.0067	0.0563	0.9631
6.5	1.5	65	0.9994	0.0006	0.0078	0.0519	1.0330
6.5	1.5	75	0.9993	0.0007	0.0086	0.0598	1.0180
6.5	1.5	85	0.9998	0.0002	0.0052	0.0543	1.0800
2.5	2	45	0.9941	0.0094	0.0212	0.0348	0.8990
2.5	2	55	0.9984	0.0023	0.0108	0.0427	0.8924
2.5	2	65	0.9961	0.0052	0.0165	0.0675	0.7990
2.5	2	75	0.9962	0.0045	0.0162	0.0917	0.7422
2.5	2	85	0.9963	0.0040	0.0164	0.0987	0.7278
3.5	2	45	0.9971	0.0042	0.0153	0.0344	0.9693
3.5	2	55	0.9989	0.0015	0.0095	0.0432	0.9413
3.5	2	65	0.9996	0.0005	0.0057	0.0621	0.8862
3.5	2	75	0.9991	0.0011	0.0085	0.0746	0.8516
3.5	2	85	0.9979	0.0024	0.0130	0.0797	0.8477
4.5	2	45	0.9987	0.0016	0.0098	0.0515	0.8728
4.5	2	55	0.9973	0.0034	0.0146	0.0583	0.8686
4.5	2	65	0.9971	0.0034	0.0151	0.0740	0.8443
4.5	2	75	0.9997	0.0004	0.0051	0.0619	0.9275
4.5	2	85	0.9993	0.0007	0.0075	0.0555	1.0180
5.5	2	45	0.9985	0.0019	0.0112	0.0287	1.1240
5.5	2	55	0.9984	0.0019	0.0117	0.0308	1.1450
5.5	2	65	0.9989	0.0013	0.0101	0.0360	1.1240
5.5	2	75	0.9981	0.0022	0.0135	0.0364	1.1580
5.5	2	85	0.9985	0.0016	0.0122	0.0461	1.1190
6.5	2	45	0.9983	0.0021	0.0126	0.0307	1.1060
6.5	2	55	0.9982	0.0021	0.0132	0.0360	1.1000
6.5	2	65	0.9993	0.0007	0.0081	0.0519	1.0290
6.5	2	75	0.9989	0.0012	0.0108	0.0451	1.1020
6.5	2	85	0.9990	0.0010	0.0106	0.0527	1.0850

determination of co-efficient for these models were 0.9913, 0.9713 and 0.9814, respectively in treated samples drying. However, in all raw meat samples drying, the highest values of determination of co-efficient for exponential Model, Henderson and Pabis Model, and Logthemic Model were 0.9897, 0.9917 and 0.9887, respectively whereas the lowest values of determination of coefficient for these models were 0.9615, 0.9692 and 0.9706, respectively.

From Table 1, the root mean square error (RMSE) and standard error of estimate (SEE) varied from 0.02121 to 0.00101 and 0.009447 to 0.0001413 for page's model in drying of treated samples but in raw samples for page's model, these errors were 0.0218 to 0.0010 and 0.0104 to 0.0002, respectively. The values of RMSE and SEE for two-term exponential model were varied from range of 0.0253 to 0.0012 and 0.0096 to 0.0002, respectively in drying of treated samples whereas the values of these errors for that model, were varied from 0.0304 to 0.0015 and 0.0114 to 0.0002, respectively in drying of raw chicken meat samples. For exponential Model, Henderson and Pabis Model, and Logthemic Model, the values of RMSE and SEE were ranged from 0.04935 to 0.001347 and 0.03248 to 0.0002682, 0.04105 to 0.005424 and 0.02528 to 0.000265, and 0.03826 to 0.001744 and 0.02086 to 0.0002545, respectively in all treated chicken meat samples drying. However, in case of raw meat chicken drying, the values of RMSE and SEE for exponential Model, Henderson and Pabis Model, and Logthemic Model were varied from 0.05379 to 0.001469 and 0.035728 to 0.000296, 0.04556 to 0.00602 and 0.028060 to 0.000294, and 0.042086 to 0.00191 and

Table 3 : Page's model statistic and constants for drying of raw chicken meat samples

Air velocity(m/s)	Size(cm^3)	Temperature(°C)	R^2	SEE	RMSE	k	n
2.5	1	45	0.9901	0.0009	0.0073	0.0459	0.9102
2.5	1	55	0.9900	0.0011	0.0082	0.0512	0.9199
2.5	1	65	0.9884	0.0031	0.0140	0.0575	0.9231
2.5	1	75	0.9885	0.0028	0.0139	0.0528	1.0040
2.5	1	85	0.9886	0.0027	0.0140	0.0485	1.0619
3.5	1	45	0.9901	0.0009	0.0077	0.0520	0.8988
3.5	1	55	0.9907	0.0002	0.0033	0.0559	0.9090
3.5	1	65	0.9899	0.0011	0.0090	0.0677	0.9020
3.5	1	75	0.9897	0.0013	0.0102	0.0642	0.9426
3.5	1	85	0.9897	0.0012	0.0104	0.0755	0.9143
4.5	1	45	0.9903	0.0007	0.0071	0.0547	0.9051
4.5	1	55	0.9895	0.0015	0.0109	0.0635	0.9087
4.5	1	65	0.9895	0.0015	0.0114	0.0542	0.9947
4.5	1	75	0.9901	0.0008	0.0085	0.0599	0.9886
4.5	1	85	0.9899	0.0010	0.0101	0.0593	1.0140
5.5	1	45	0.9902	0.0008	0.0078	0.0431	0.9975
5.5	1	55	0.9900	0.0009	0.0091	0.0513	0.9841
5.5	1	65	0.9904	0.0005	0.0070	0.0576	0.9849
5.5	1	75	0.9906	0.0002	0.0051	0.0528	1.0200
5.5	1	85	0.9900	0.0008	0.0098	0.0611	1.0310
6.5	1	45	0.9897	0.0014	0.0106	0.0363	1.0729
6.5	1	55	0.9901	0.0008	0.0084	0.0466	1.0460
6.5	1	65	0.9899	0.0010	0.0098	0.0530	1.0360
6.5	1	75	0.9898	0.0011	0.0109	0.0553	1.0599
6.5	1	85	0.9899	0.0009	0.0105	0.0507	1.1239
2.5	1.5	45	0.9899	0.0015	0.0089	0.0479	0.9479
2.5	1.5	55	0.9894	0.0021	0.0109	0.0374	0.9674
2.5	1.5	65	0.9899	0.0012	0.0086	0.0471	0.9397
2.5	1.5	75	0.9897	0.0015	0.0097	0.0531	0.9605
2.5	1.5	85	0.9894	0.0017	0.0109	0.0507	1.0000
3.5	1.5	45	0.9896	0.0016	0.0098	0.0593	0.8145
3.5	1.5	55	0.9895	0.0016	0.0102	0.0757	0.7765
3.5	1.5	65	0.9893	0.0018	0.0113	0.0856	0.7788
3.5	1.5	75	0.9898	0.0097	0.0010	0.0887	0.7981
3.5	1.5	85	0.9900	0.0009	0.0086	0.0783	0.8732
4.5	1.5	45	0.9900	0.0011	0.0083	0.0444	0.9439
4.5	1.5	55	0.9889	0.0026	0.0133	0.0433	0.9882
4.5	1.5	65	0.9895	0.0016	0.0109	0.0506	0.9868
4.5	1.5	75	0.9895	0.0015	0.0110	0.0529	1.0090
4.5	1.5	85	0.9896	0.0014	0.0111	0.0586	1.0020
5.5	1.5	45	0.9900	0.0010	0.0087	0.0593	0.8618
5.5	1.5	55	0.9899	0.0011	0.0094	0.0596	0.8868
5.5	1.5	65	0.9892	0.0018	0.0126	0.0759	0.8537
5.5	1.5	75	0.9897	0.0012	0.0106	0.0818	0.8531
5.5	1.5	85	0.9901	0.0007	0.0086	0.0812	0.8781

Table 3 contrd…

Contd…. Table 3

6.5	1.5	45	0.9890	0.0022	0.0129	0.0528	0.9359
6.5	1.5	55	0.9903	0.0006	0.0069	0.0540	0.9621
6.5	1.5	65	0.9902	0.0007	0.0081	0.0498	1.0320
6.5	1.5	75	0.9901	0.0007	0.0088	0.0574	1.0170
6.5	1.5	85	0.9906	0.0002	0.0053	0.0522	1.0789
2.5	2	45	0.9850	0.0104	0.0218	0.0334	0.8981
2.5	2	55	0.9892	0.0026	0.0111	0.0410	0.8915
2.5	2	65	0.9869	0.0057	0.0170	0.0648	0.7982
2.5	2	75	0.9870	0.0049	0.0167	0.0880	0.7415
2.5	2	85	0.9871	0.0044	0.0169	0.0947	0.7271
3.5	2	45	0.9879	0.0047	0.0158	0.0330	0.9683
3.5	2	55	0.9897	0.0017	0.0098	0.0414	0.9404
3.5	2	65	0.9904	0.0006	0.0059	0.0596	0.8853
3.5	2	75	0.9899	0.0012	0.0087	0.0716	0.8507
3.5	2	85	0.9887	0.0026	0.0134	0.0765	0.8469
4.5	2	45	0.9895	0.0018	0.0101	0.0495	0.8719
4.5	2	55	0.9881	0.0037	0.0150	0.0560	0.8677
4.5	2	65	0.9879	0.0037	0.0155	0.0710	0.8435
4.5	2	75	0.9905	0.0004	0.0053	0.0594	0.9266
4.5	2	85	0.9901	0.0008	0.0077	0.0533	1.0170
5.5	2	45	0.9893	0.0021	0.0116	0.0276	1.1229
5.5	2	55	0.9892	0.0021	0.0121	0.0295	1.1439
5.5	2	65	0.9897	0.0015	0.0104	0.0345	1.1229
5.5	2	75	0.9889	0.0024	0.0139	0.0350	1.1568
5.5	2	85	0.9893	0.0018	0.0125	0.0442	1.1179
6.5	2	45	0.9891	0.0023	0.0130	0.0294	1.1049
6.5	2	55	0.9890	0.0023	0.0136	0.0345	1.0989
6.5	2	65	0.9901	0.0008	0.0084	0.0498	1.0280
6.5	2	75	0.9897	0.0013	0.0111	0.0433	1.1009
6.5	2	85	0.9898	0.0011	0.0109	0.0506	1.0839

0.02294 to 0.00028, respectively. It was cleared that for page's model, root mean square error and standard error of estimate were lower in comparison with others mathematical model such as two-term exponential Model, exponential Model, Henderson and Pabis Model and Logthemic Model for all these cases of drying treatments. The Page model gave highest co-efficient of determination (R^2) with the lowest RMSE and SEE as shown in Table 2. The Page model has been mostly used to characterize the drying curves of food product. Therefore page's model may be selected to characterize the thin layer drying behavior of chicken meat samples. Pacheco *et al*. (2011) stated a similar observation for hot air drying of fish feed.

From Fig. 2, Page's model was best fitted in experimental moisture ratio data resulted in good agreement between predicted moisture ratio and observed moisture ratio. This similar observation was reported by Guan *et al.* (2013) for hot drying of fresh tilapia fillets.

Conclusion :

In this study, the selection of best drying model based on performance of various models comparing the statistical parameters namely high co-efficient of determination and minimum values of RSME and SEE of these five drying models, the Page' model was selected as best model than other mathematical models. It was observed that a good agreement between experimental moisture ratio and predicted moisture ratio values at different drying conditions, as they both rested around straight line for page' model. This recommended that

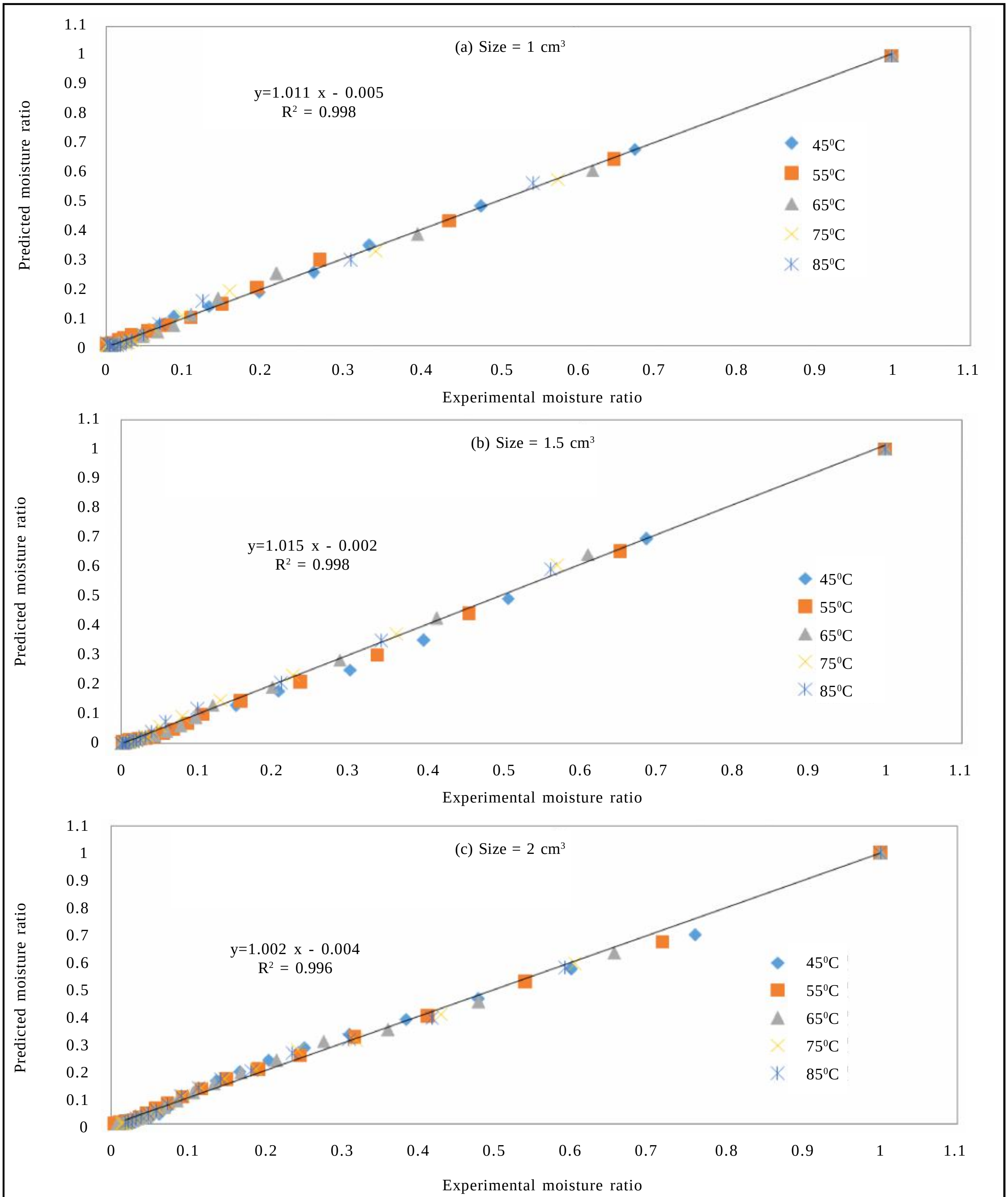

Fig. 2 : Experimental moisture ratio and predicted moisture ratio of Page's model during hot air drying of chicken meat samples

Page's model could be used to describe drying behaviour of chicken meat dying. It was cleared that page's model was well fitted in experimental data obtained from drying, with maximum value of determination co-efficient (R^2), followed by Henderson and Pabis model and others mathematical models.

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