STATISTICAL ANALYSES ON THE MODELLING OF *PANGASIUS FISH* ON AN INCUBATOR WITH DIFFERENT TEMPERATURES

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Abstract:Drying experiment of thin layer of fish (split in a butterfly style from ventral side) was conducted in a University of Dehradun, Uttarakhand. An incubator was used for drying the fishes under three different temperatures (50^0, 60^0 and 70ºC) and sample weight were continuously observed/recorded every one-hour interval. Data had been regressed to twelve mathematical models to estimate a appropriate model for drying of pangasius fish. The models were compared primarily based on their coefficient of dedication (EF), root mean square error (RMSE), and reduced chi-square (X^2). Midilli & Kucuk version had the highest value of EF, the bottom RMSE and X^2.

Index Terms **– Drying, pangasius fish, incubator, modeling, moisture ratio.**

I. INTRODUCTION

Drying is one of the most established strategies for protection of fish which improves the solidness of fish by decreasing the water and microbial movement, limiting physical and concoction changes amid capacity (Darvishi et al, 2012). This acquires a generous decrease weight and volume, limiting bundling, stockpiling and transportation costs (Vega-Galvez et al, 2009). Traditionally sun drying of fish was done under the open sun, a minimal effort conservation system utilized from days prehistoric to safeguard the fish (Jain and Pathcare, 2007). The confinement to control climate conditions, drying procedure and parameter, high work cost, bug invasion, the necessity of substantial drying zone, blending with residue and other outside particles (Jain and Pathcare, 2007) long preparing time and poor cleanliness of item have prompted the advancement of oven dryers or sunlight-based dryers. Hot air drying utilizes convection framework with controlled air speed and mugginess, high temperatures yet includes high vitality utilization, bacterial tainting and conceivable quality change (Selmi et al, 2010).

Fish is an important source of protein because of its high dietary benefit, great quality proteins containing the vast majority of the fundamental amino acids and essential minerals, for example, phosphorus, calcium, magnesium and so forth. (Chukwu, 2009, Jain and Pathcare, 2007, Seroyer-E-Mahfud et al, 2012). Fish is one of the most perishable foods because of its suitable medium for spoilage after harvest. High surrounding temperature common in tropics is in charge of quicker waste and disintegration of tropical species. Subsequently fast conservation of fish is vital which incorporates conventional strategies like salting or brining, sun drying, sun powered drying, air drying and smoking in smoking ovens (Mustapha et al., 2014).

Fish is one of the proteins sustenance's that needs watchful handling (Eyo, 2004*).* This is because fish ruins effectively after catch because of the high tropical temperature which quickens the exercises of microscopic organisms, catalysts and synthetic oxidation of fat in the fish. Because of poor taking care of, around 30 –50% of fish collected are squandered. These misfortunes could be limited by the utilization of appropriate dealing with, preparing and protection systems (Bate and Bendall, 2010). The reason for preparing and saving fish is to get fish to an extreme customer in great, usable condition. The means important to achieve this start before the angling campaign begins, and don't finish until the fish in eaten or handled into oil, dinner, or a feed (Kabure et al, 2001). Fish starts to ruin when it is gotten, maybe even before it is removed from the water. Along these lines, the way to conveying an excellent item is close thoughtfulness regarding little subtleties all through the whole procedure of arrangement, getting, landing, taking care of, capacity, and transport. Fish that winds up ruined or rotten is clearly unusable (Jayakumar, 2000). Fish that is inadequately thought about may not be so clearly terrible, yet it loses esteem on account of off-flavours, soft surface, or awful shading that dishearten (Burt, 2003), a potential buyer from purchasing. In the event that clients have gotten one terrible fish, they most likely won't purchase another. Then again, on the off chance that you reliably convey great quality at a reasonable value, individuals will end up faithful clients (Nelson et al, 2004). Decay continues as a progression of complex enzymatic bacterial and chemical changes that start when the fish is gotten or snared (Burt, 2003). This procedure starts when the fish bites the dust. The rate of waste is quickened in warm atmospheres. The fish's gut is a rich wellspring of proteins that enable the living fish to process its nourishment (Lima Dos Santos et al, 2011). When the fish is dead, these proteins start processing the stomach itself. In the end the proteins move into the fish fragile living creature and review it as well. This is the reason the fish turns out to be delicate and the smell of the fish turns out to be increasingly recognizable. There are incalculable microscopic organisms normally present on the skin of the fish, in the gills, and in the digestive organs (Kabure et al, 2001). Regularly, these microscopic organisms are not unsafe to a living fish. Not long after death, in any case, they start to increase, and following two to four days they ingest the tissue of even a very much frosted fish as enzymatic processing diminishes it. The bacterial burden conveyed by a fish relies upon its wellbeing, its condition, and in transit it was gotten. Sound fish, from clean water, will keep superior to anything fish hauled along the base of a messy lake in a trawl net. Both enzymatic absorption and bacterial decay include substance changes that reason the well-known smells of waste (Potro, 2005). Oxygen likewise responds synthetically with oil to cause rotten scents and taste. The point of fish preparing and protection is to back off or keep this enzymatic, bacterial, and compound crumbling, and to keep up the fish substance in a condition as close as conceivable to that of new fish (Bate and Bendall, 2010).

Pangasius has moved toward becoming as one of the candidate species for aquaculture in India because of its high generation rate. However, use of Pangasius in new structure has got restriction and there is an earnest need to discover alternative methods for handling as minimal effort preparing and curing is one of such method. Higher moisture content of the substance will make the item helpless to microbial and enzymatic decay. *Pangasius* having a moisture content of 78% is liable to spoilage if not preserved properly. In spite of the fact modern preservation techniques are accessible; they are expensive for farmers and fishermen. So, curing of fish, which is an ease conservation strategy and effectively versatile can be utilized as a technique for protection of *Pangasius*. Higher temperature will prompt quicker drying rate and shorter drying time (Guan et al, 2013).

The aim of the prevailing examine is to broaden a mathematical modelling of thin layer drying of Pangasius fish at one-of-a-kind drying temperatures of 50, 60 and 70º C at regular air speed of 3.6 m/s.

II. MATERIALS AND METHODS

2.1 Raw materials and processing

Fish was purchased from the fish market in Ghanta Ghar, Uttarakhand, India and was immediately bought to University laboratory within one hour. Upon arrival to the laboratory, the fish have been washed with water to put off dust and slime. The fish were already beheaded and eviscerated and thereafter split from the ventral side in butterfly style. The butterfly style cut fish were used for drying. Few amounts of salt were smeared to the fish for fast drying and reduction of microorganisms and was dried inside an incubator.

2.2 Mathematical Modeling of Dying curves:

The drying curves received were processed to discover the most convenient considered one of 12 exclusive expressions defining drying rates, as given in table 1, with the aid of numerous investigators (Lui et al, 1997, O'callaghan et al, 1971, Agrawal et al, 1997, Zhang et al, 1991, Overhults et al, 1973). 630 experiments of fish were performed with different temperatures (50, 60 and 70°C) at a constant air velocity of 3.6m/s. The initial moisture content material of the fish become observed 51.94% become reduced to the final moisture content material of 1.17 % on wet foundation.

Within the literature, there are numerous statistical take a look at strategies used to assess statistically the overall performance of the drying models. Amongst these, the mean bias error (MBE), the root means square error (RMSE) and the reduced chi-square (χ^2) are the most extensively used ones (Torgul et al, 2002, El–Sebaii et al, 2002, Midilli et al, 2003, Akpinar et al, 2003, Ertekin et al, 2004; Midilli et al, 2002, Yaldiz et al, 1991, Sarsavadia et al, 1999), as given below.

Table 1: Mathematical models given by various authors for the drying curves

Model No.	Model name	Model equation	References
1	Lewis	M_R= exp (-kt)	(Lui et al,1997, O OCallaghan et al, 1971)
2	Page	M_R= exp (-kt^n)	(Agarwal et al, 1997, Zhang et al, 1991)
3	Modified page	M_R= exp[(-kt)^n]	(Overhults et al, 1973, White et al., 1981)
4	Henderson and Pabis	M_R= aexp (-kt)	(Hendreson and Pabis, 1961) Chhinnan, 1984, Westerman et al, 1973)
5	Yagcioglu et al.	M_R= aexp (-kt) + c	(Yagcioglu et al, 1999)
6	Two-term	M_R= aexp (-k_ot) + bexp(-k_1t)	(Henderson, 1974, Rahman et al, 1998)
7	Two-term exponential	M_R= aexp (-kt) + (1-a)exp(-kat)	(Sharaf-Elden et al, 1980)
8	Wang and Singh	M_R =1+at+bt^2	(Wang and Singh, 1978)
9	Diffusion approach	M_R= aexp (-kt) + (1-a)exp(-kbt)	(Kassem, 1998)
10	Verma et al.	M_R= aexp (-kt) + (1-a)exp(-gt)	(Verma et al, 1985)
11	Modified Henderson and Pabis	M_R= aexp (-kt) + bexp(-gt) +cexp(-ht)	(Karathanos, 1999)
12	Midili and Kucuk	M_R= exp (-kt^n) + bt	(Midili et al, 2002)

2.2.1. Mean Bias Error (MBE):

The mean bias error is calculated as:

$$MBE = \frac{1}{N}\sum_{i=1}^{N}(M\,r_{pre,i} - Mr_{exp,i}) \qquad (1)$$

2.2.2. Root Mean square error (RMSE):

The root mean square error can be calculated with the aid of the subsequent equation. It provides the information on the quick-term performance. The value of RMSE is always positive, represented as zero in the ideal case.

$$RMSE = \sqrt{\left[\frac{1}{N}\sum_{i=1}^{N}(M\,r_{pre,i} - Mr_{exp,i})^2\right]} \qquad (2)$$

2.2.3. Reduced chi-square (χ^2):

The reduced chi-square can be calculated by the subsequent equation where *n* is the wide variety of constants. The lower are the values of the reduced χ^2, the higher is the goodness of fit.

$$\chi^2 = \frac{\sum_{i=1}^{N}(M\,r_{exp,i} - Mr_{exp,i})^2}{N-n} \qquad (3)$$

2.2.4. Efficiency (EF):

The model efficiency can be calculated by the following equation.

$$EF=\frac{\sum_{i=1}^{N}\left(MR_{i,exp}-MR_{i,expmean}\right)^2-\sum_{i=1}^{N}\left(MR_{i,pre}-MR_{i,exp}\right)^2}{\sum_{i=1}^{N}\left(MR_{i,exp}-MR_{i,expmean}\right)^2} \quad (4)$$

2.2.5. Moisture ratio (M_R):

The moisture ratio is defined as follows:

$$M_R=\frac{m-m_{exp}}{m_o-m_{exp}} \quad (5)$$

III. RESULT AND DISCUSSION

During drying of salted *Pangasius fish* inside an incubator, a decrease in moisture content was observed. The diminish in moisture content might be expected of the misfortune about free water introduce in muscle because of entrance for heat, also salt. Throughout drying, the water action will diminish yet the fat, protein also carbohydrate contents build for water loss, ph changes, expansion of free ammio acids, furthermore fatty acids might have been accounted (Collignan et al, 2008). This technique can be used to supply desirable fine dried product for domestic consumption in addition to export marketplace. The statistical analyses of dried pangasius fish were fitted in twelve different models. Out of which the Midilli and Kucuk model was the most adequate version in describing the drying techniques of pangasius fish. The least suitable models were the Lewis and Modified page models. The result shows that, in all drying temperatures, the very best value of EF (0.99954) and lowest value of X^2 (4.4E-05) and RMSE (0.00606) obtainable with the Midilli and Kucuk model. The tables below are the result of statistical analysis on the modelling of pangasius fish inside an incubator with three different temperatures (50^0C, 60^0C and 70^0C) and steady drying air speed of 3.6m/s.

Table 2: Result of statistical analyses on the modelling of *Pangasius* fish on an incubator with 50^0C.

Model	Model Constant	Correlation Coefficient	MBE	RMSE	X^2	Efficiency
Lewis	k=0.060445	0.99592	-0.00374	0.025612	0.000669	0.990629
Page Model	k=0.041129, n=1.129008	0.99841	-0.00385	0.015973	0.000266	0.996793
Modified Page Model	k=0.059224, n=1.129017	0.99841	-0.00385	0.015973	0.000266	0.996793
Henderson And Pabis Model	a=1.040258, k=0.062868	0.99685	-0.00608	0.022515	0.000528	0.993338
Yagcioglu et al	a=1.094033, k=0.050429, c=-0.08854	0.99967	-3.8160E-05	0.051375	5.62E-05	0.999344
Two Term	a=0.520132, k0=0.062868, b=0.520132, k1=0.06287	0.99685	-0.00607	0.159206	0.000551	1.006662
Two Term Exponentials	a=0.005686, k=10.50651	0.99562	-0.00509	0.02653	0.000733	0.989837
Wang And Singh	a=-0.04434, b=0.00051	0.99611	-0.00527	0.02501	0.00065	0.99281
Diffusion Approach	a=-7.03638, k=0.09528, b=0.93755	0.99861	-0.00331	0.01496	0.00024	0.99717
Verma et al	a=-5.27162, k=0.09639, g=0.08857	0.99861	-0.00334	0.01497	0.00024	0.99716
Modified Henderson and Pabis	a=0.34675, k=0.06287, b=0.34675, g=0.06287, c=0.34675, h=0.06287	0.99685	-0.00608	0.02252	0.00058	0.99334
Midilli and Kucuk	a=1.00855, k=0.0545, n=1.00029, b=-0.00141	0.99968	-4.9501E-06	0.00719	5.60E-05	0.99936

Table 3: Result of statistical analyses on the modelling of *Pangasius* fish on an incubator with 60^{0}C.

Model	Model Constant	Correlation Coefficient	MBE	RMSE	X^2	Efficiency
Lewis	k=0.10045	0.99009	0.00229	0.03595	0.00135	0.98034
Page Model	k=0.05842, n=1.2258	0.99678	-0.00226	0.01943	0.00041	0.9953
Modified Page Model	k=0.31694, n=0.31694	0.99009	0.00229	0.03595	0.00141	0.98034
Henderson and Pabis Model	a=1.05556, k=0.10626	0.99227	-0.00342	0.03129	0.00107	0.98695
Yagcioglu et al	a=1.27186, k=0.06516, c=-0.26923	0.99969	0.00062	0.00658	5E-05	0.99946
Two Term	a=0.52778, k0=0.10626, b=0.52778, k1=0.10626	0.99227	-0.00342	0.03129	0.00118	0.98695
Two Term Exponentials	a=1.7502, k=0.13806	0.99654	-0.00183	0.01977	0.00043	0.99503
Wang And Singh	a=-0.07442, b=0.0014	0.99883	-0.00081	0.01272	0.00018	0.99805
Diffusion Approach	a=-6.57599, k=0.18052, b=0.91358	0.99687	-0.0016	0.01876	0.0004	0.99555
Verma et al	a=0.1, k=0.10045, g=0.10045	0.99009	0.00229	0.03595	0.00148	0.98034
Modified Henderson And Pabis	a=0.35158, k=0.10626, b=0.35185, g=0.10626, c=0.35185, h=0.10626	0.99227	-0.00342	0.03129	0.00131	0.98695
Midilli And Kucuk	a=1.00934, k=0.08138, n=0.97623, b=-0.00728	0.99976	0.00043	0.00606	4.4E-05	0.99954

Table 4: Result of statistical analyses on the modelling of *Pangasius* fish on an incubator with 70^{0}C

Model	Model Constant	Correlation Coefficient	MBE	RMSE	X^2	Efficiency
Lewis	k=0.17582	0.98239	-0.00237	0.05911	0.00376	0.95339
Page Model	k=0.08713, n=1.38009	0.99647	-0.00681	0.02657	0.00082	0.99291
Modified Page Model	k=0.41931, n=41931	0.98239	-0.00237	0.05911	0.00408	0.95339
Henderson and Pabis Model	a=1.07034, k=0.18813	0.98589	-0.01093	0.05297	0.00327	0.96825
Yagcioglu et al	a=1.42149, k=0.09819, c=-0.4082	0.99871	6.9184E-09	0.01605	0.00033	0.99742
Two Term	a=0.53517, k0=0.18813, b=0.53517, k=0.18813	0.98589	-0.01093	0.05297	0.00393	0.96825
Two Term Exponentials	a=1.88685, k=0.25967	0.99519	-0.00756	0.03101	0.00112	0.98994
Wang And Singh	a=-0.12594, b=0.00377	0.99900	0.00075	0.01414	0.00023	0.99798
Diffusion Approach	a=-13.4258, k=0.3455, b=0.94322	0.99586	-0.00688	0.02877	0.00089	0.99144
Verma et al	a=0.00598, k=0.17582, g=0.17582	0.98239	-0.00237	0.05911	0.00445	0.95339
Modified Henderson And Pabis	a=0.35678, k=0.18813, b=0.35678, g=0.18813, c=0.35678, h=0.18813	0.98589	-0.01093	0.05297	0.00491	0.96825
Midilli And Kucuk	a=0.99497, k=0.10071, n=1.17271, b=-0.01017	0.99901	-1.0477E-05	0.0141	0.00028	0.99801

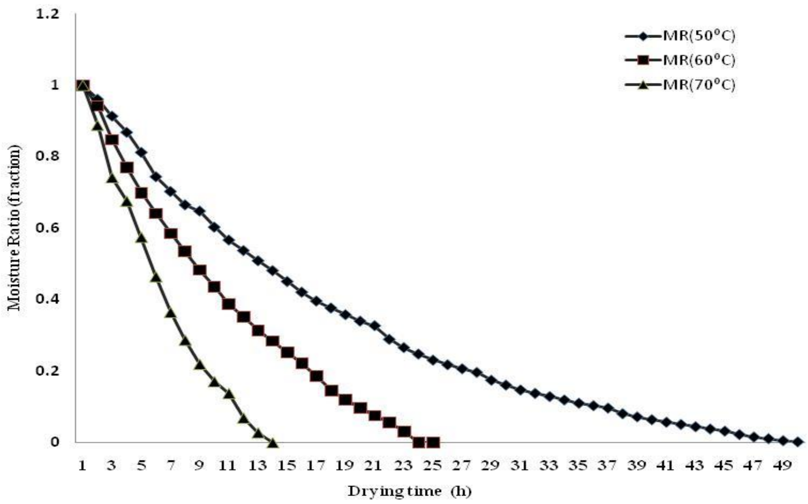

Fig 1: Relationship between the moisture ratio and drying time

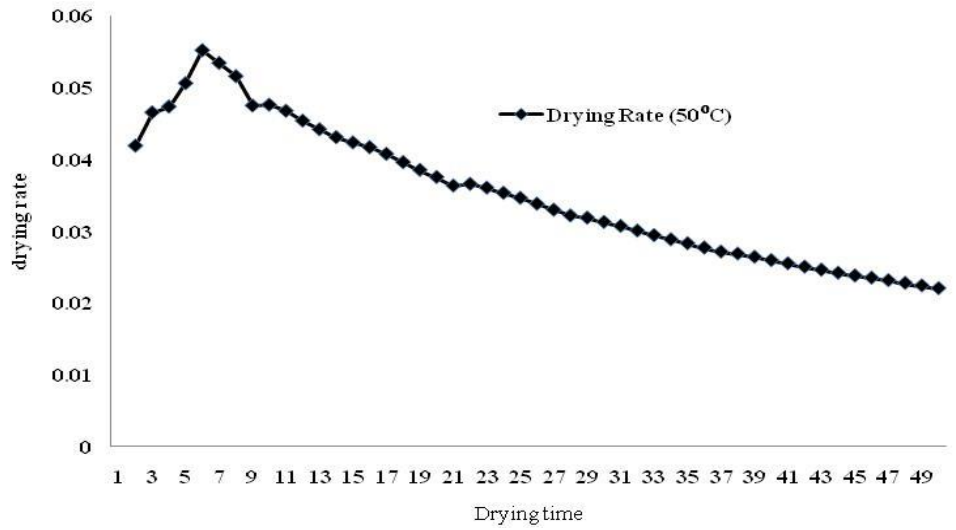

Fig 2: Drying rate versus drying time at 50^0 C

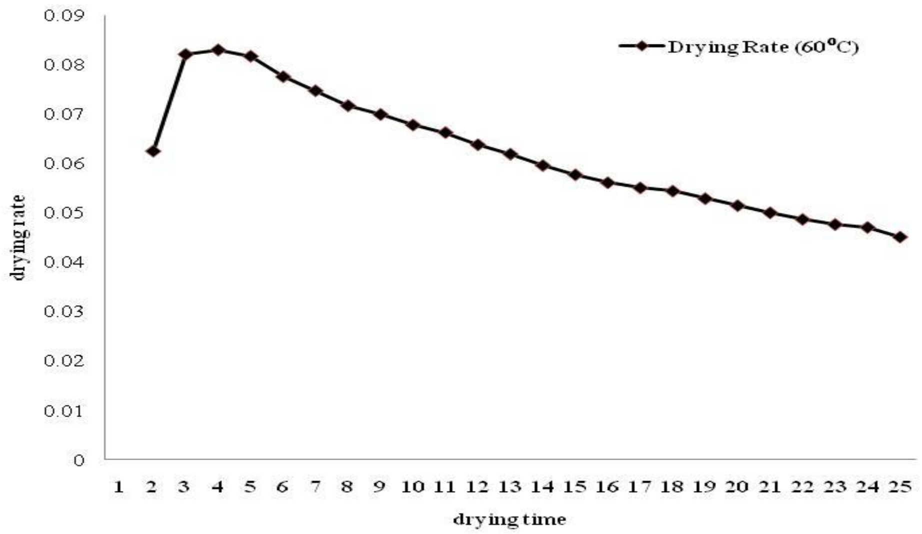

Fig 3: Drying rate versus drying time at 60^0 C.

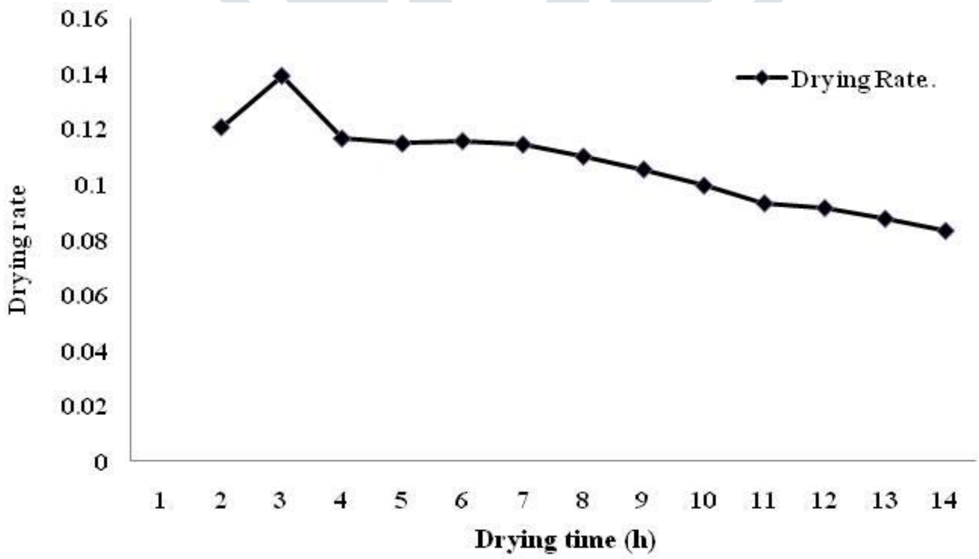

Fig 4: drying rate versus drying time at 70^0 C .

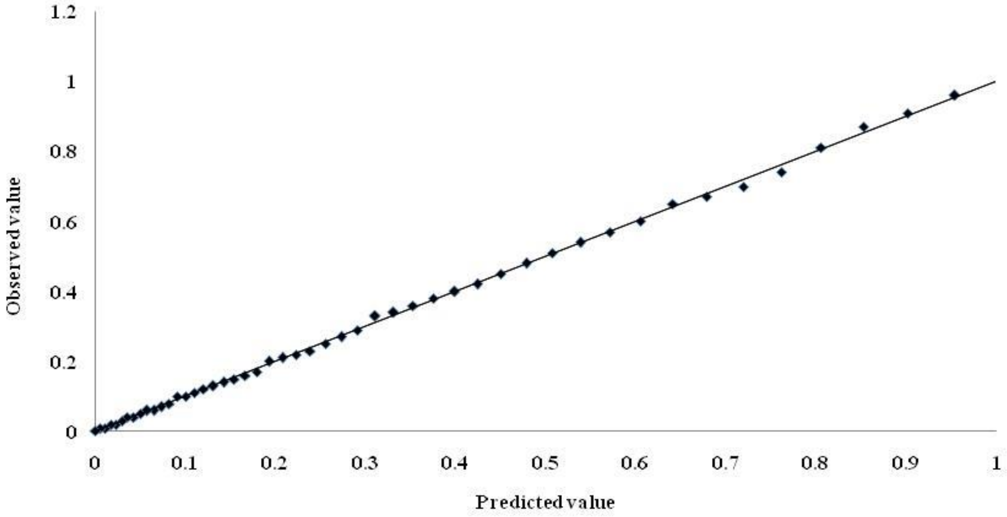

Fig 5: Midilli's observed and predicted moisture ratios at 50° C.

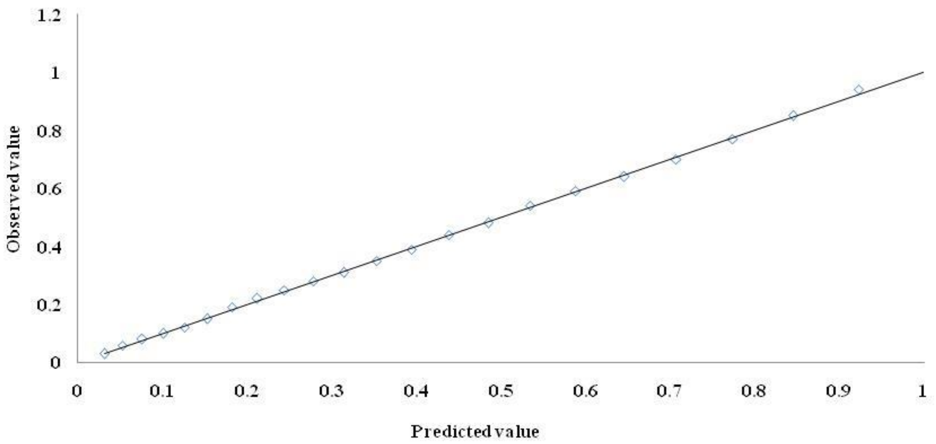

Fig 6: Midilli's observed and predicted moisture ratios at 60° C.

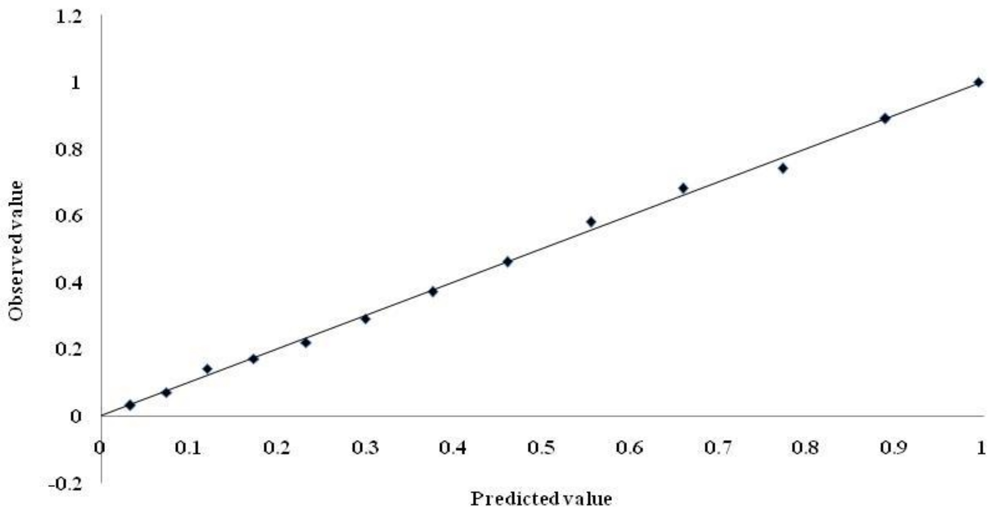

Fig 7: Midilli's observed and predicted moisture ratios at 70° C.

IV. CONCLUSION

The drying behaviour of *Pangasius* fish inside an incubator was investigated at 3 different temperatures (50, 60 and 70° C). Hence the drying rate extended with drying air temperature, for this reason decreasing the drying time. The Midilli and Kucuk model was found to be satisfactorily describing the drying behavior of *Pangasius fish* at constant air velocity 3.6m/s.

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