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## Optimize Newton statistical models for fish drying by using regression analysis

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### Abstract

Stripped Mullet (in odia it is called Dangla) having zoological name Juvenile mugil under the family of Mugilidae species (fishes) were selected as a drying material in three different methods like sun drying, solar drying and poly house drying. Drying characteristics were studied and compared among them. A natural convective direct heating solar dryer and Poly-house dryer were used in experiments as well as natural sun drying experiment was conducted on an open surface. The weight of the sample and other drying parameters were recorded in every one hour of interval from 9:00 am to 5:00 pm everyday during the experimental period. Regression was carried out by using excel software to determine the drying parameters and developed Newton mathematical model. The model efficiencies were found to be 99.62 %, 99.55 % and 98.53% for solar drying, poly-house drying and sun drying respectively.

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### Keywords:

Stripped Mullet;  
Poly-house drying;  
Regression;  
Data analysis;  
Model efficiency

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### 1. Introduction

Drying of fish after harvesting is vital role for processing and preservation of fish for a longer period of time in hygienic manner. In fact most of the fish is handled in an unhygienic way. Sun drying which is an older technique to utilizing solar radiation for drying the fish is a traditional approach by the coastal area of Odisha, which is really an unhygienic method and inefficient method of drying. Solar drying and Poly house drying are provide controlled fish drying which can't achieved in open sun drying methods.

India is blessed with an 7500 km long coastline and an exploitable marine fish reserve of 4.57 million tons in country's Exclusive Economic Zone (EEZ) [1]. Odisha is a state on the eastern seaboard of India, located between 17° 49' and 22° 36' North latitudes and between 81° 36' and 87° 18' East longitudes. It spreads over an area of 1,55,707 sq km. and is broadly divided into four geographical regions, i.e. Northern Plateau, Central River Basins, Eastern Hills and Coastal Plains. It has a 480 km coastline (about 8% of coastline India). The Coastal Plains form an extensive alluvial tract lying between the Eastern Ghat hill ranges and the coast. It stretches for about 480 km and is

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six maritime districts in the state: Balasore, Bhadrak, Kendrapara, Jagatsinghpur, Puri and Ganjam. These six districts cover 14.5% of the total land area in the state [2-4].

Chilika Lake is Asia's largest brackish water lagoon with water spread ranging from 1165 km<sup>2</sup> in the rainy season to 906 km<sup>2</sup> in the dry season is nestled in the heart of the coastal Odisha for fish, prawn and crab fisheries. The main species of fish caught in Chilika include mullets, sciaenids, threadfins, catfish, hilsa, clupeids, perches, *Etroplus suratensis*, shrimp species including *Penaeus monodon*, *P. indicus*, *P. semisulcatus*, *Metapenaeus monoceros* and crab species such as *Scylla serrata* and *Neptunus pelagicus* [5].

In literature survey it was found that nearly 10 to 12 million ton per year of post-harvest fish lose not due to proper handling, which is about 10% of the total fish production. Hence it is time to analyse the factor seriously and preserves them technically to improve income of society and also to get hygienic products [6].

## 2. Theory

Initial mass, final mass of the sample, oven dried mass, Moisture Content, Moisture Ratio, drying rate are some of the major drying parameters of the specimen required for investigation. In this research investigation average moisture content on dry basis was considered for analysis. Here the specimen (Stripped Mullet) was kept in an electric oven maintained at a temperature of 105<sup>o</sup> c for 24 hours to obtain oven dried mass of the specimen. Eq.1, eq.3 and eq.4 are providing the mathematical formulae for moisture content, moisture ratio and drying rate respectively [7-11].

$$M_C = \left( \frac{X_I - X_O}{X_O} \right) \times 100\% \quad (1)$$

$$M_R = \frac{M_t - M_e}{M_I - M_e} \quad (2)$$

$M_e$  Value is negligible as compared to  $M_t$  and  $M_I$ , hence the equation can be reduced to eq. 3 [7-11]

$$M_R = \frac{M_t}{M_I} \quad (3)$$

$$D_R = \frac{M_{t+dt} - M_t}{dt} \quad (4)$$

Where  $M_C$ =Moisture Content

$M_R$ =Moisture Ratio

$X_I$  =Initial weight of the sample

$X_O$  =Oven dried weight of the sample

$M_t$  =Moisture content of the sample at any instant of time

$M_e$  =Equilibrium moisture content of the sample

$M_I$  =Initial Moisture content of the sample

t =Time interval

## 3. Research Method

A hybrid solar dryer and poly house solar dryer are already installed inside the college premises by the College of Agricultural Engineering and Technology (CAET), under Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, India. Some basic features of the hybrid solar dryer are that it has about 5 kg capacity having three numbers of selves. In the bottom part there is an arrangement of burning chamber which is useful for burning the biomass and supply the heat

to the product for drying in the absence of solar radiation, particularly an efficient heating during the rainy season. The dryer is integrated with chimney, blowers, photovoltaic panel, thermocouples for efficient heating and performing the experiment. as shown in figure.1.



Figure 1. Hybrid solar dryer

Experiments were conducted on the solar dryer, poly house dryer and open sun drying. Marine fish samples (Stripped Mullet) which is widely available in the lake Chilika (coastal belt of Odisha) was chosen for our experimental study. The sample was purchased from local market of Bhubaneswar (Chilika Fresh) just before sampling. Electronic balance was used to measure the weight of the sample in each one hour interval of drying. Other drying parameters like variation in temperature, relative humidity, solar radiation, air flow rate also recorded.

### 3.1. Geographical Location

College of Agricultural Engineering & Technology Bhubaneswar (CAET)  
University: Orissa University of Agriculture and Technology (OUAT)  
Latitude: 20<sup>o</sup>15'N  
Longitude: 85<sup>o</sup>52'E  
State: Odisha  
Country: India

### 3.2. Sample Preparation

Before starting the drying experiment, the specimen has undergone three vital processes named “cleaning” “brining” and “washing” for accurate investigation. The susceptible organs present inside the fish were removed, and then put them inside a brine solution prepared by dissolving almost 350 grams of salt in one litter of water for 20 minutes. The specimen was turned inside the solution for better homogeneity. Wash the sample (as shown in figure. 2) with tap water properly and kept on a screen for dripping out the excess water. Now the samples were dried in the three different methods (sun drying, solar drying and poly-house drying) till equilibrium moisture content achieved.



Figure 2. Stripped Mullet

(Sample)

#### 4. Regression analysis

Some statistical tools can be used for regression analysis to find out the drying parameters involved in Newton mathematical model like Coefficient of Determination ( $R^2$ ), Modeling Efficiency (EF), Reduced Chi-square ( $\chi^2$ ), Root Mean Square Error (RMSE). (Togrul and Pehlivan, 2002; Demir, *et al.*, 2004).

Data analysis in excel software has been used in this current investigation.

$$\chi^2 = \frac{\sum_{i=1}^N (M_{Rexp,i} - M_{Rpre,i})^2}{N - n}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (M_{Rexp,i} - M_{Rpre,i})^2}{N}}$$

$$EF = \frac{\left[ \sum_{i=1}^N (M_{Rexp,i} - M_{Rexp,mean})^2 \right] - \left[ \sum_{i=1}^N (M_{Rpre,i} - M_{Rexp,mean})^2 \right]}{\left[ \sum_{i=1}^N (M_{Rexp,i} - M_{Rexp,mean})^2 \right]}$$

Newton mathematical model [12] is given by in eq.5

$$M_R = \exp(-k.t) \quad (5)$$

Where

$M_{Rexp,i=i^{th}}$  experimental moisture ratio

$M_{Rpre,i=i^{th}}$  Predicted moisture ratio

N=Number of observations

n=Number of Constants (Aghbashloo *et al.* 2009; Yaldiz *et al.* 2001)

The higher the  $R^2$  value and lower the  $\chi^2$  and RMSE values, the better is the goodness of fit [13-14].

#### 5. Results and Analysis

By using Microsoft excel software drying plots are drawn for three different drying methods (Sun, Solar & Poly-house) and got the result of statistical parameters. Data analysis was used for regression analysis to find the value of MBE, RMSE,  $\chi^2$  and  $R^2$ . The comparative results are shown in table: 1. Refere the figure. 3 & 4 for sun drying, figure. 5 & 6 for solar drying and figure.7 & 8 for poly-house drying respectively. The comparison study of variation of moisture content for the specimen with respect to drying time is shown in figure. 9.

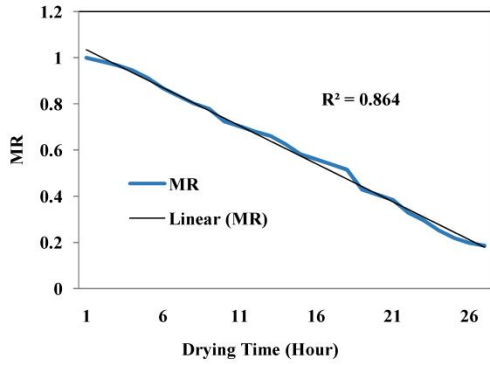


Figure 3. Variation of MR with drying time (Sun Drying)

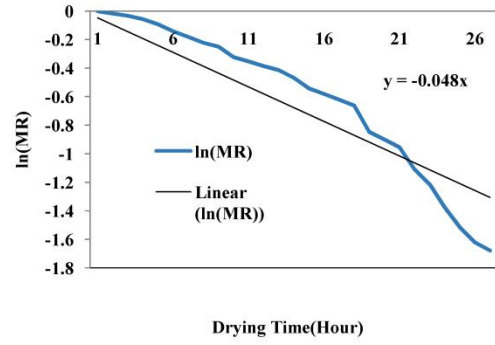


Figure 4. Variation of ln(MR) with drying time (Sun Drying)

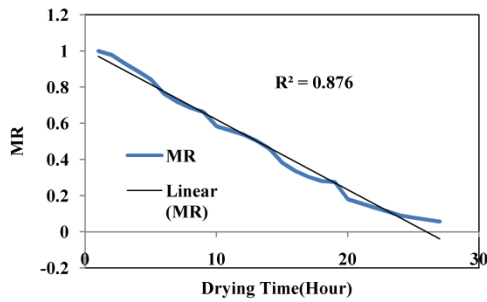


Figure 5. Variation of MR with drying time (Solar Drying)

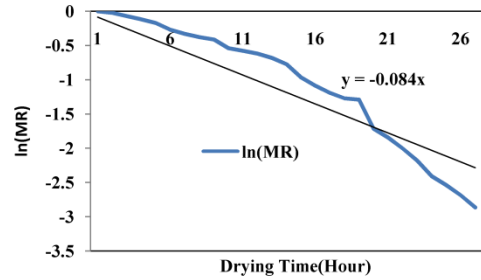


Figure 6. Variation of ln(MR) with drying time (Solar Drying)

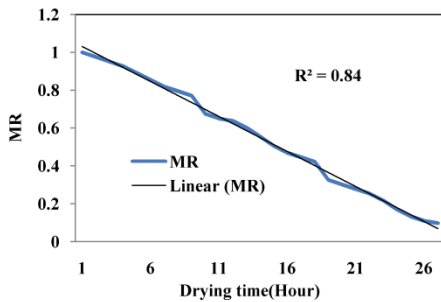


Figure 7. Variation of MR with drying time (Poly-house Drying)

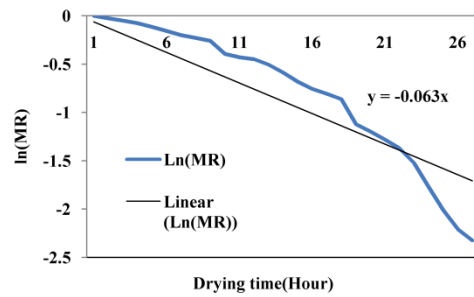


Figure 8. Variation of ln(MR) with drying time (Poly-house Drying)

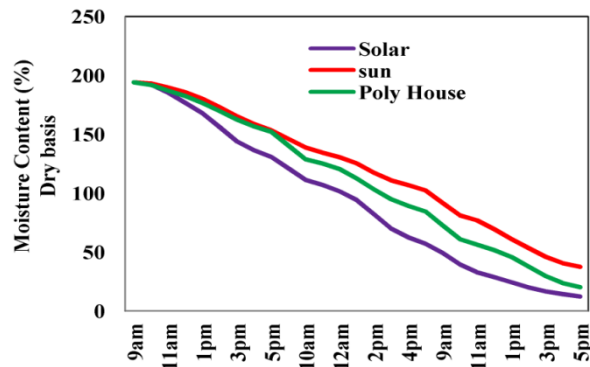


Figure 9. Variation of Moisture Content with drying time

Table 1 .Statistical analysis of Newton Mathematical Model

| Methods of drying | Drying Parameters |             |             |             |                |             |
|-------------------|-------------------|-------------|-------------|-------------|----------------|-------------|
|                   | K                 | MBE         | RMSE        | $\chi^2$    | R <sup>2</sup> | EF          |
| Sun Drying        | 0.048             | 0.000295622 | 0.017193648 | 0.001410344 | 0.864          | 98.53505395 |
| Solar Drying      | 0.084             | 0.01165379  | 0.01165379  | 0.000307    | 0.876          | 99.6197349  |
| Poly-houseDrying  | 0.063             | 0.00031655  | 0.0177917   | 0.00032872  | 0.84           | 99.5522563  |

## 6. Conclusion

A statistical mathematical model (Newton) is proposed to describe the drying characteristics of the specimen being dried. The model provides the efficient drying method of the specimen. Experiment were conducted for a specimen of Stripped Mullet in three different drying methods such as open sun drying, solar drying and poly house drying and compare the results among them. The best efficient method of drying found in this investigation is solar drying followed by poly-house drying and sun drying. Fig. 9 clearly indicates that rate of drying is fast in solar drying as compared to others.

Drying was conducted continuously for three days from 9:00 am to 5:00 pm with an effective drying time of 24 hours. It is observed that the moisture removal is 81.24%, 90.19% and 94.27% in open sun drying, poly-house drying and solar drying respectively.

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