*The Journal of Rural and Agricultural Research Volume 24 No. 2, 128-132 (2024)*
*Received October 2024; Acceptance December 2024*

# Drying behaviour of freshly harvested paddy in low cost STR dryer

ASHOK KUMAR[1], SATISH KUMAR*, MOHAN KUMAR SINHA[2], MANISH KUMAR[3] AND JITENDRA KUMAR[4]
*College of Agricultural Engineering, Ara, Bhojpur (BAU, Sabour)*
** Corresponding e-mail:* skumarbau@gmail.com *(corresponding Author)*

**Abstract**

*In India machines are widely used in agriculture for harvesting and threshing, moisture content of freshly harvested paddy is being high as much as 18-24%. The mechanical threshers or combine harvesters with elevated capacity enable for both harvesting and threshing at once. Thus, the paddy harvested all over persists with high moisture content that affects adversely in unit operations of paddy processing such as cleaning, storing, and milling. The research was conducted to overcome this problem by developing a mobile paddy dryer that can be used at field level for freshly harvested paddy. A STR dryer with 5tone capacity was developed and tested for drying freshly harvested paddy. The grains were dried in dryer at temperatures of 50 and 60 °c and air velocities of 1.5, 2.0, 2.5 and 3.0 m/s. Duration of drying of paddy from 24.78 % to 10.5 % moisture content (w.b.) was 3.5–7 h depending upon the source of energy used. Kinetics of l*a*b* were measured. The results showed that with increase in drying time, l* decreased, but a* and b* increased. The effect of air temperature and air velocity on the l*a*b* values were significant (p< 0.01) and not significant (p> 0.05), respectively. Changing of color values at 60°C was more than other temperatures. The over-all drying performance of the dryer was found to be good. This dryer is widely accepted by small and marginal farmers.*

Keywords: Kinetics, temperature, energy, velocity, paddy, moisture content

## Introduction

India is the second largest rice producer in the world (timesindia.com). It is also reported that postharvest losses of food grains were about 15-18 % due to improper handling and adequate facility available with the farmers. Inadequacy of proper drying methods is the major reason for such huge amount of food loss. Proper drying involves reducing the moisture content of the paddy grains to acceptable levels. Moisture content of 14% (wb) is the proper moisture content for storing and preserving paddy grains. There are several methods for drying paddy. One of the common methods used in India for drying paddy post harvesting is open sun drying. This traditional method of drying has many drawbacks like improper drying of food grains, food contamination by dust and insects, loss of food by birds and rodents etc. Alsoopen sun drying method can be utilized only during the day time on sunny days only. Drying reduces bulk quantity, thus, facilitates in transportation, handling and storage. If the moisture content of paddy is inappropriate for storage, it will be exposed to fungal diseases and chemical reactions and damaged after paddy

[1]Mandan Bharti Agricultural College, Agwanpur, Saharsa (BAU, Sabour)
[2]Department of Ag. Engg., IRS, Araria (BAU, Sabour)
[3]Nalanda College of Horticulture, Noorsarai, Nalanda (BAU, Sabour)
[4]Department of Ag. Engg., IRS, Madhepura (BAU, Sabour)

husking (Mehdizadeh and Zomorodian, 2012). In this context, it is important to understand the temperature and moisture distributions inside the grain bulk during drying. In view of long time taking and unhygienic way of sun drying a low cost STR dryer has been developed and data was reported on moisture loss, drying rates and drying kinetics of paddy during drying.

## Materials and Methods

*Sample preparation*

A freshly harvested variety of paddy (Rajendra sweta) was procured from directorate of seed and farm, BAU, Sabour, Bhagalpur in the state of Bihar (India) for this study. A randomly selected sample was, then cleaned to remove any impurities followed by mechanical grading to achieve quality paddy ready to dry.

*Initial Moisture Content*

Hot air oven method was used to determine the initial moisture content of the selected paddy. A pre weighed paddy sample of 15 g was kept in a pre-dried and weighed moisture box in oven at 80ºC for 24 hours (Ranganna, 2002). The dried samples were cooled in desiccators to room temperature and then weighed using electronic balance and moisture content (w.b.) of sample which was expressed as g water/g dry matter was used for calculations.

*Design and development of STR Dryer*

The STR dryer consists of inner bin, outer bin, hot air pipe, blower (fan) with 1 hp motor and stove (Chula). The dryer is modified with attaching 1 hp motor, provision of gate valve for ambient air entry and 15° slope at bottom for easy discharge of dried grains. The diameter of outer bin is adjustable to hold desired volume of paddy sample. The dryer is made of two perforated concentric cylinders with grains inside the annular space. Hot air allows to pass from top to bottom through the inner prepared cylinder bin grains inside the annular space. An axial flow blower is used to suck the hot air from the stove (Chula) through iron pipe and force the air radially through perforated bins (Fig. 1 and 2). Locally available rice husk briquette is used as fuel in a portable locally made stove.

*Dryer installation procedure*

The STR dryer was installed and tested at department of Agricultural Engineering, Bihar Agricultural University, Sabour for paddy. At first, surface must be levelled where dryer to be installed. Once dryer installed on level surface, 500 kg of paddy was filled in annular space. The axial flow blower was set up on the top of the inner bin of the dryer and a polythene cover was used to protect hot air leaking from the paddy of the dryer using bricks. A stove (Chula) was placed in one side of the grain bin and firing was done using rice husk briquette. Then the hot air supply pipe was fixed with stove at one end and drying chamber with another end.

*Parameters observation during drying*

Moisture content and temperature were measured from nine locations inside the bin during the operation. Among the nine locations namely $T_1$.....$T_9$ and $M_1$......$M_9$ respectively. Moisture content at $M_1$ and $M_2$maintaining 45 and 55 cm from centre of inner bin; $M_3$, $M_4$, $M_5$ maintaining 65, 50, 35; $M_6$, $M_7$, $M_8$ and $M_9$ maintaining a distance of 65, 50, 35 and 65 cm distance from centre line of inner bin during drying operation. The experimental runs of vertical drying were conducted at initial moisture content of 21.5, 22.5, 23.10 and 24.78 % (w.b.) with four air velocities (1.5, 2.0, 2.5 and 3.0 m/s). The moisture content was measured using probe sensor digital moisture meter at a time interval of 10 min during first hour of drying, 30 min for second hour and 60 min for third hour till the end of drying. Drying was terminated when the grains reached at Equilibrium moisture content.

*Colour measurement*

Colour is important to consumer as a mean of identification, as a method of judging quality and for its basic aesthetic value and food is no exemption. The overall objective of colour to the food is to make it appealing and recognizable. The most common technique to assess the colour is colorimeter. There are several colour scales used in a Hunter Lab Colorimeter such as $L^*$ $a^*$ and $b^*$ which represented the surface colour. The colour values are obtained as $L^*$ is the lightness coefficient, ranging from 0 (black) to 100 (white), $a^*$ is purple-red (positive $a^*$ value) and blue-green (negative$a^*$ value). a* and $b^*$, that represents yellow (positive $b^*$ value) or blue (negative $b^*$ value) colour (McGuire, 1992).

Colour of the dried paddy was measured using a Hunter Lab Colorimeter. A cylindrical glass sample cup (6.35 cm dia. x 4 cm deep) was placed at the light port (3.175 cm dia). Each sample was measured for colour values three times. The instrument was initially calibrated with a black as well as with standard white plate. From these values chroma (C) was calculated according to following relation as suggested by (Pomeranz and Meloan, 1971.

Fig. 1 Photographic viewof modified STR dryer

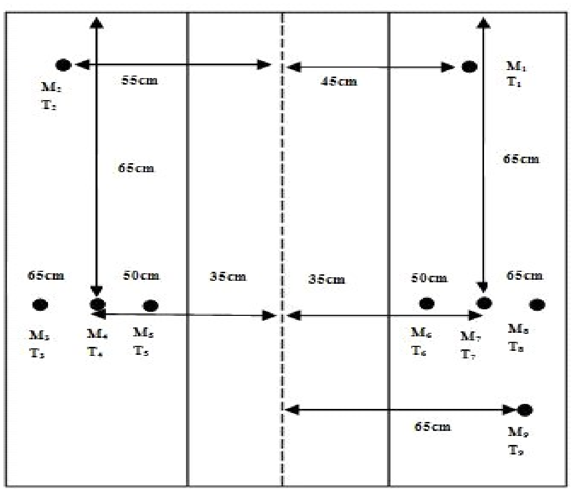


Fig. 2: Temperature & Moisture measured at different locations of the dryer

$$h^0 = \arctan (b^*/a^*)$$

$$C = \sqrt{(a^*)^2 + (b^*)^2}$$

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where;

$$\Delta L^* = L^* - L^*_{st}$$

$$\Delta a^* = a^* - a^*_{st}$$

$$\Delta b^* = b^* - b^*_{st}$$

Where, st subscript represents L*, a* and b* values of a standard rice.

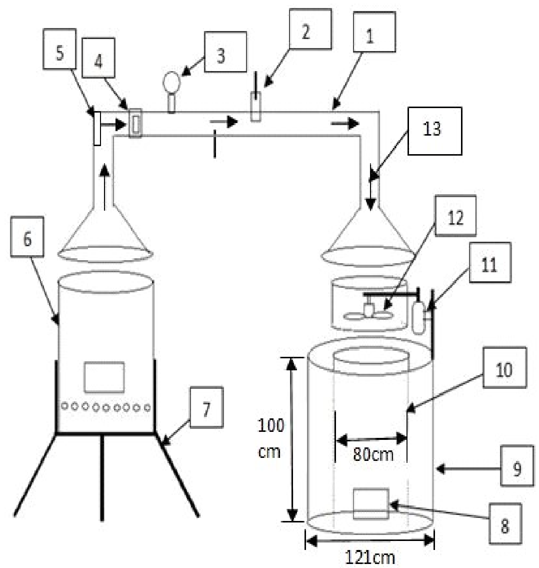


Fig.3: Schematic diagram 1. Hollow pipe 2. Digital temperature sensor 3. Pressure gauge 4. Digital anemometer 5. Gate valve 6. Stove 7. Tripod ewwsesw stand 8. Discharge gate 9. Outer cylindrical bin 10. Perforated inner cylindrical bin 11. Motor 12. Fan and 13. Hot air

## Results and Discussion

*Drying Curves*

The initial moisture content of paddy was 24.78 % (wb) and the equilibrium moisture content was 10.5 % (wb) when no more change in moisture content during drying was observed. The moisture content versus drying time for paddy at selected air velocity (1.5, 2.0, 2.5 and 3.0 m/s) and air temperature (50 and 60 p C) as shown in fig 1 and 2. According to the results, drying air temperature played an important role in drying process. When the air velocity was increased, the drying time was reduced. At the initial period of drying process, moisture content decreased significantly in the experiments. Also, as can be seen in Fig. 1 and 2 for air temperature of 50p C the drying time of paddy were 450, 390, 270 and 210 min at air velocity of 1.5, 2.0, 2.5 and 3.0 m/s respectively. Whereas Figure 2 represents for air temperature of 60p C the drying time of paddy were 390, 300 240 and 180 min at air velocity of 1.5, 2.0, 2.5 and 3.0 m/s respectively. The lowest drying time was acquired at air velocity of 3.0 m/s. Similar results were reported by Golpour *et al.,* (2015) for paddy, Ratti*et al*. (2007) for garlic, Arumuganathan *et al.* (2009) for mushroom, and Kaleta and Gornicki (2010) for red beet drying.

*Color Analysis*

The average measured color indices of the fresh paddy were 60.12, -7.28 and 14.71 for *L*, a** and *b**, respectively. Color change conditions and the effects of the various air velocity, different air temperature, and *L*a*b** values showed that the color changing characteristics at higher air velocity were more than on other air velocity. As a result, the changing of color values at 3.0 m/s at 60°C was more than other velocity and temperatures (Figures 3 and 4) because, with increasing air velocity, the husk surface of paddy became darker and the variations of the sample color increased after drying process. The average values of *L*, a** and *b** were obtained in the drying process at three iterations.

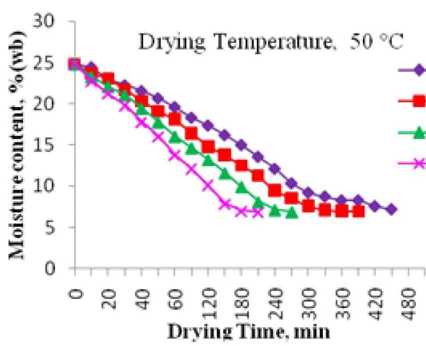


Fig.1: Effect of air different air velocity on drying curve at drying temperature of 50 °C

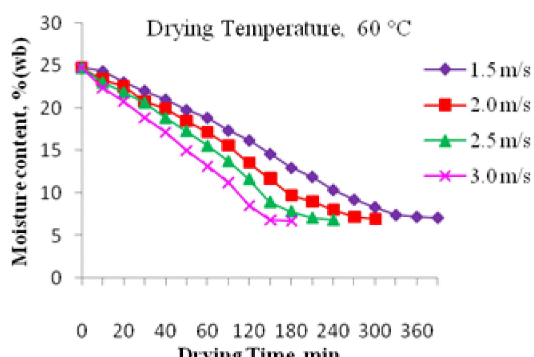


Fig.2: Effect of air different air velocity on drying curve at drying temperature of 60 °C

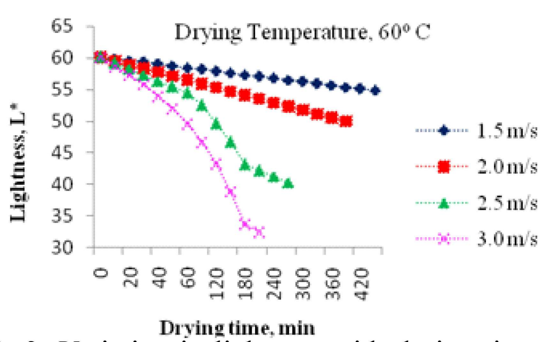


Fig.3: Variation in lightness with drying time at different air velocity at temperature of 60 °C

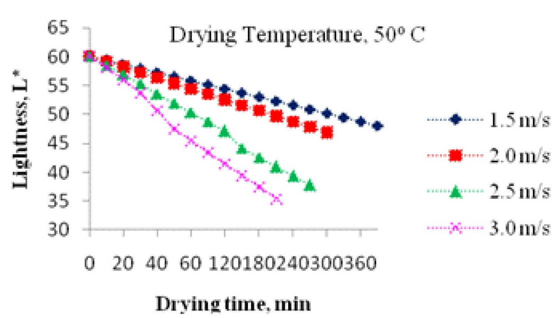


Fig.4: Variation in lightness with drying time at different air velocity at temperature of 50 °C

The $L^*$ values of paddy during the drying process decreased with increase in drying time and velocity. Brightness change of the dried samples can be taken as a measurement of browning (Lee and Coates, 1999). Values of $a^*$ and $b^*$ increased with increase in drying time (Fig. 3 and 4), so that these results were similar to those reported by Shafafi Zenozian *et al.* (2008). Paddy sample was darker compared to the original sample after drying (with the final moisture content about 8-10% wb). Color change indices at various air temperatures are presented in Figures 3- 4. At all air velocities, the lowest $L^*a^*b^*$ values corresponded to air temperature of 50°C and the highest values were recorded at air temperature of 60°C. This nonlinearity in color feature changes may be due the distortion resistance of the paddy crust at the early period of moisture decline. In other words, at the initial stages of drying, free water was removed from capillary tubes without causing a significant variation in the color of the paddy. After this stage, the color features gradually changed. One of the other reasons of the paddy color changes was pigment degradation of paddy. This result is similar to that of Wan *et al.* (2011) and Golpour*et al*., (2015) for paddy.

## Conclusion

The drying behavior of paddy in STRdryer and relationship of moisture content ofthe samples with color features at four air velocity of 1.5, 2.0, 2.5 and 3.0 m/sand two temperature 50 an 60 °C was investigated. The air velocity hadsignificant effect on the $L^*$, $a^*$, and $b^*$ valuesat probability of 0.01 (P< 0.01). The $L^*$ values of paddy during the drying process decreased and the $b^*$ (yellowness) and $a^*$ (redness) values increasedwith increase in drying time and velocity. At all air velocities, the lowest $L^*a^*b^*$ values corresponded to air temperature of 50°C and the highest values were recorded at air temperature of 60°C. The results showed that the air velocity plays a significant role for complete drying of paddy. A good agreement between model predictions and experiments at different velocities was obtained.

## References


http://timesofindia.indiatimes.com/

Mehdizadeh, L.; Zomorodian, A. and Mowla, A. (2012). Applying Artificial Neural Network for Drying Time Prediction of Green Pea in a Microwave Assisted Fluidized Bed Dryer. *J. Agric.Sci. Technol*14**:** 513–522.

Ranganna, S. (2002). Handbook of Analysis and Quality Control for Fruits and Vegetable Products (II Edition). Tata McGraw Hill Publishing Co. Ltd., New Delhi.

McGuire, R.G. (1992). Reporting of Objective Color Measurements. Horticulture Science 27: 1254-1255

Pomeranz, Y. and Meloan, C. E. (1971). Food Analysis: Theory and Practice. Molecular Nurtion Food Research16(7):808–809.

Golpour, I.; Amirim, C. R.; Amiri, P. J. and Khazaei, J. (2015). Prediction of Paddy Moisture Content during Thin Layer Drying Using Machine Vision and Artificial Neural Networks. *J. Agr. Sci. Tech.17: 287-298.*

Lee, H.S. and Coates, G.A. (1999). Vitamin C in frozen fresh squeezed unpasteurised polyethylene bottle orange juice: a storage study. *Food Chem.*65: 165–168.

ShafafiZenozian, M.; Feng, H.; Razavi, S. M. A.; Shahidi, F. and Pourreza, H. R. (2008). image Analysis and Dynamic Modeling of Thin-layer Drying of Osmotically dehydrated Pumpkin. *J. Food Process. Preserv.*, 32:88–102.

Katela A and Gornicki, K. (2010). Some remarks on evaluation of drying models of red beet particles. Energy Conversion and Management; 51(12):2967-2978.