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# Performance evaluation of modified STR dryer

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**Abstract**
The main objective of this study was to improve the design of an existing STR crop dryer with a view to improve its drying efficiency, reduce the drying time and produce hygienic and quality dried wheat and maize. Modifications were made on the design of the existing dryer by installing a temperature regulation mechanism and a high volumetric capacity centrifugal fan to blow hot air from the heat supply unit to the drying chamber. The dryer consisted of two perforated concentric cylinders with grains inside the annular space. Air was passed from the inner cylinder through walls with bottom and top closed to dry the grains inside the annular space. Experiments were conducted on modified STR dryer with 60 $^0$C drying air for wheat and maize at various levels of initial moisture content. It was seen that the modified STR dryers was able to remove moisture at the rate of 2.15 to 2.66% (w.b) per hour for wheat crop and at the rate of 2.30 to 2.85% (w.b) per hour for Maize crop.

**Keywords:** Dryer, modify, performance, drying rate, moisture

## 1. Introduction
All efforts of agricultural engineering has been paid attention to post harvest technology to enhance grain quality, mostly milling quality properties. Major grain quality problems can be listed as broken grain, risks in aging and storage, variety mixing and mislabeling, no dis criminating different grain sizes for commercial request. Specific grain properties relevant in drying include moisture content (both critical and equilibrium moisture content), and hull or husk tightness. Delayed drying may result in sack burning of wet grain due to non-enzymes browning and microbial growth and toxin production.
For small and marginal farmers, issues in grain drying have been discussed at harvesting time. Constraints could be identified as (1) lack of compatible technologies; (2) lack of understanding of the mechanical drying process in both design and operation; and (3) lack of extension activities. In the other hands, we have to pay more attention to the current situation of smallholders in which field varies from 0.5 to1.0 hectare per farm, and almost farmers are poor so that they have not enough money to invest modern mechanical dryers. To meet the demand of these small-holders on post-harvest of production, studies on low cost dryers focused some key features as low capacity (one to two tons per batch), simple structure, easy fabrication, low cost investment, low energy consumption, short drying time and good quality of drying product.
STR dryer is a low cost batch dryer developed by Centre for Agricultural Energy and Machinery, Nong Lam University, Vietnam and Japan International Research Center for Agricultural Sciences (JIRCAS). The design was based on the principle of low-temperature drying (a few degree above ambient air), and aims to small-scale farmers cultivating less than 0.5 ha, but living in area with electricity available. The investment for this dryer was only 20,000 INR with the drying capacity of 0.5 ton in 8 hours. This dryer consists of two perforated concentric cylinders made of bamboo with grains inside the annular space. Air is passed from the inner cylinder through walls with bottom and top closed to dry the grains inside the annular space. An axial flow blower is used to suck the hot air from the stove (Chula) through steel pipe and force the air radially through perforated bins.

## 2. Materials and Methods
### 2.1 Modification in STR dryer
The STR dryer was modified to improve the drying efficiency and ease in drying operation (Fig 1 and Fig 2). Following modifications were made against the conventional STR dryer

1. The two cylinders were made from metal sieves in order to ensure the durability of the dryer.
2. The dryers were constructed on a elevated platform using legs for easy discharge of grains.
3. An air shutters were provided at the outlet pipe of Chulha and above the inner cylinder in order to control the temperature of hot air by allowing the fresh air through the opened shutters.
4. The position of the motor was above the inlet of hot air in order to prevent it from getting heated by hot air from chulha.
5. The length of pipe conveying the hot air from chulha to dryer was reduced in order to prevent heat loss and material loss.
6. A high volumetric capacity centrifugal fan was installed to improve drying rate.

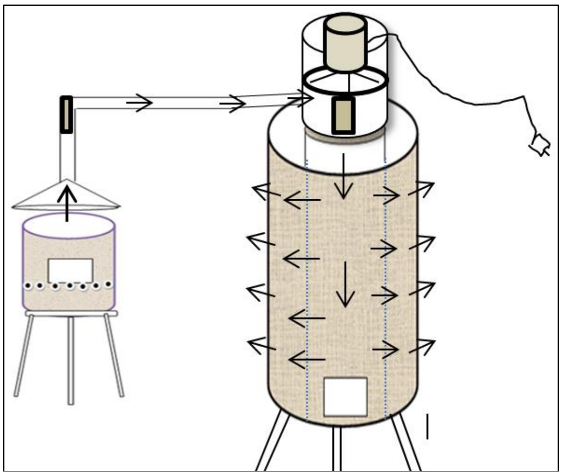

**Fig 1:** Schematic view of modified STR dryer


**Fig 2:** Pictorial view of modified STR dryer

**Table 1:** Dryer dimensions

| | Items | Specification |
|---|---|---|
| I | **Blower** | |
| | Diameter, cm | 40.0± 0.10 |
| | Height, cm | 21.0 ± 0.10 |
| | Motor size, HP | 1.0 |
| | Operating voltage, V | 220-240 |
| | Frequency, Hz | 50 |
| | RPM | 2800 |
| | Fan sweep, cm | 12 |
| II | **Inner bin** | |
| | Material | Wire mesh, stainless steel |
| | Diameter, cm | 40 |
| | Length, cm | 100 |
| III | **Outer bin** | |
| | Material | Wire mesh, stainless steel |
| | Diameter, cm | 102± 0.10 |
| | Length, cm | 100 |
| IV | **Stove (Chula)** | |
| | Diameter, cm | 40 |
| | Length, cm | 37 |
| | Placement of the iron rods for holding fuels, cm | 20 |
| | Opening for air flow at the bottom H×W, cm | 8 × 11 |
| | Stand height for chulha, cm | 62.50 |
| V | **Conveyance pipe** | |
| | Total length of pipe for hot air movement from chulha to Dryer, cm | 217.50 |
| | Diameter of conveyance pipe, cm | 7.5 |
| VI | **Metal Funnel at Chulha** | |

| | | |
|---|---|---|
| | Height, cm | 25.00 |
| | Diameter, cm | 46.00 |
| VII | **Metal Funnel at Dryer** | |
| | Height, cm | 25.00 |
| | Diameter, cm | 43.00 |
| | **Batch capacity (maximum), kg** | 500 |

### 2.2 Drying Experiment
The modified STR dryer was tested for its performance evaluation with wheat and Maize grains. The grains were delivered in the annular space of the dryer in such a way so that equal the grain contained in all sides. After complete filling of the grain, 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. A stove was placed in one side of the grain bin and firing was done using biomass briquette. Then the hot air supply channel was conveyed to the dryer.

Samples were drawn with the help of steel made auger for the moisture content determination from fifteen locations maintaining 25, 35 and 45 cm distance from the center line of inner bin during drying operation. The moisture content measurement locations were fixed considering grain thickness in the dryer (Fig 3). The moisture content of grains were measured using a digital moisture meter (Indowsaw; accuracy: ± 0.2% 105C). Data were collected at regular interval in order to determine the moisture removal.

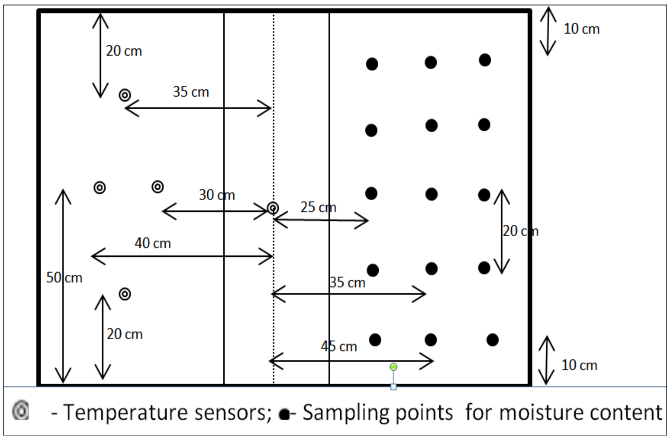


**Fig 3:** Experimental set up of STR dryer

To determine the spatial distribution of temperature sensors were used in vertical and horizontal axis (Fig 3). The four thermocouples were set up in different points of the dryer to get the temperature reading during drying operation (Fig 3). The thermo couples set up position were varied with sample size of grain. The air velocity through the blower was measured by using a digital anemometer at the suction and delivery point of the blower. The experiment was conducted with three treatments and three replications.

## 3. Results and Discussions
The air temperature used for drying the grains ranged between 55 to 65 ºC. The air velocity at the suction side and delivery side were 6.8 ± 0.2 cm/sec and 6.5 ± 0.15cm/sec respectively.

The STR dryer was tested for wheat grain. It was observed that the grain close to inner cylinder had maximum moisture loss as compared to grain close to outer cylinder. It was clear from fig 4 that the initial moisture content of was 19.45 (% wb) and after drying the final moisture content (% wb) were 10.69, 11.14 and 11.41%for grains at three locations i.e. inner, middle and outer respectively. It was seen that moisture of 8.75% (w.b.) was removed in 4 hours (Fig 4) i.e. around 2.25% moisture content was removed per hour.

From the figure 4 it is clear that the moisture content during the drying process decreases with time which is in the compliance with the nature of drying characteristics of various researches made for drying of fruit vegetable & cereals (Lyderson (1983) [7] and Gabriela *et al.* (2004) [6]. The reason for the above-mentioned nature of the drying rate curve is that initially the moist yam chips surface act as a free water surface and the rate of moisture migration from the interior of the product to the surface. With time, there is decrease in the wet surface and hence the drying rate decreases, as drying proceeds the fraction of wet surface decreases to zero where drying process ceases.

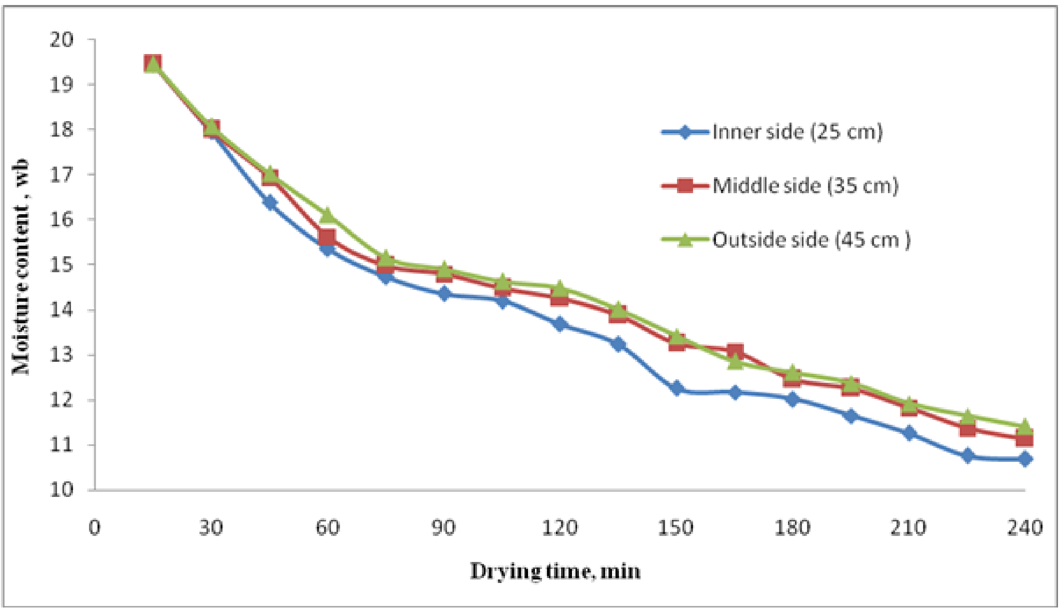


**Fig 4:** Drying curve for wheat grain between moisture content versus drying time

The STR dryer was also tested for maize grain. It was observed that the grain close to inner cylinder had maximum moisture loss as compared to grain close to outer cylinder. It is clear from fig 4 that the initial moisture content of was 20.45 (% wb) and after drying the final moisture content (% wb) was 10.76, 10.79 and 10.84% for grains at three locations i.e. inner, middle and outer respectively. It was seen that moisture of 9.986% (w. b.) was removed in 4 hours (Fig 4) i.e. around 2.5% moisture content was removed per hour.

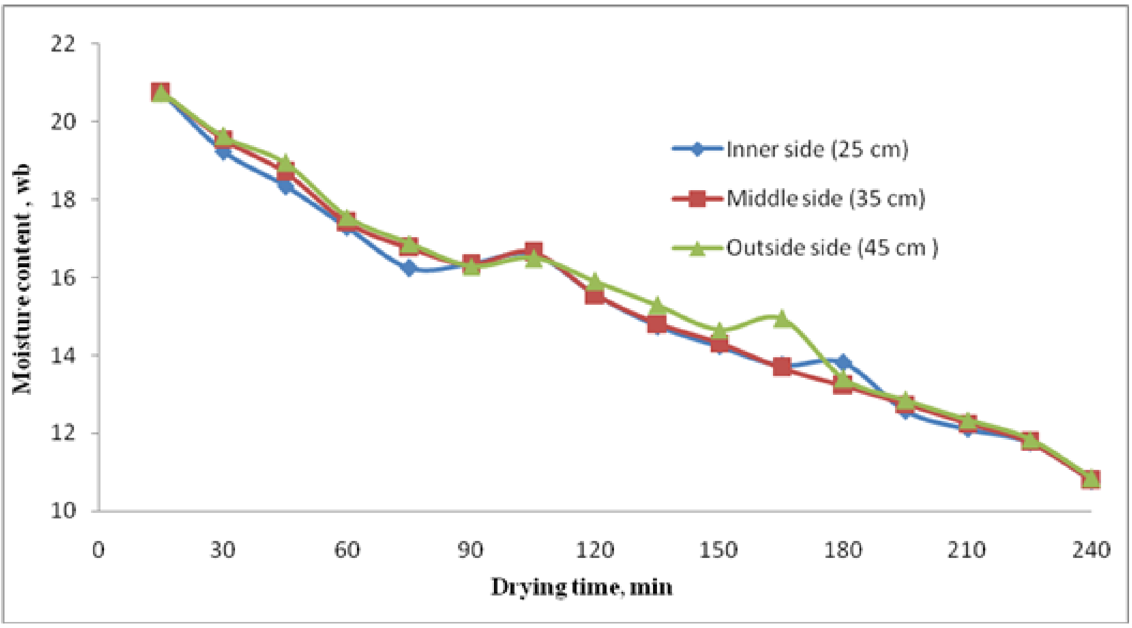


**Fig 5:** Drying curve for maize grain between moisture content versus drying time

## 4. Conclusion

Modified STR dryer off ereda good drying performance with drying rate of around 2.5% per hour Investment cost was very less, can be operated on farm/biomass wastes and can be recommended for adoption by small and marginal farmers at times when rapid or fast drying is required or when the sun drying becomes ineffective.

## 5. References


1. Baker CGJ. The design of flights in cascade rotary dryers, Drying Technology, 1988, 631-653.
2. Brooker DB, Fred Bakker-Arkema W, Carl Hall W. Drying Cereal Grains, Westport, Connecticut, The bAVI publishing company, Inc., 1974.
3. Brooker DB, Fred Bakker-Arkema W, Carl Hall W. Drying and Storage of Grains. An AVi Book published by Van Nost rand Reinhold, New York, 1992.
4. Cham RR, Highley E, Johnson G. Grain Drying in ASIA, Aciar proceedings, No. 71. Australian Centre for International Agricultural Research, Canberra, 1996.
5. Champ BR, Highley E, Johnson GJ. Grain Drying in Asian, ACIAR Proceedings, N0 71. Australia Centre for Internatinal Adricultural Research, Canberra, 1996.
6. Gabriela A, Pompeu T, Paulo C, Carneiro F, Hilary C. Osmotic Dehydration of Mango: Effects of Temperature and Process Time, International Sugar Journal. 2004; 12(8):70.
7. Lyderson AL. Mass Transfer in Engineering Practice. John Wiley and Sons publishing company, New York, 1983.