Development of large scale drying system for Chillies (*Capsicum annum*)

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Abstract: A study was conducted to investigate large scale drying of ripe chillies in unutilized tobacco barns. Experiments indicated that ten quintals of ripe chillies can be loaded in a 6 m×3.6 m size barn. Galvanized iron wire mesh trays of size 105 cm×75 cm×7.5 cm were found to be suitable to spread chillies on the existing tiers. Drying time required to reduce moisture from 292.5% to 9.6% (db) varied considerably depending upon whether chilli pods were thin pericarp type varieties or thick pericarp type hybrids. The hybrids took about 40 hours to dry whereas the varieties took about 24 hours. Drying air temperatures ranging initially at 50℃ to a final value of about 55℃ were found to be appropriate to dry chillies. Open yard sun drying took 12 and 17 days for varieties and hybrids respectively. The discoloured pods were low, 3.5%- 4% in barn dried process in comparison to 12% to 14% in open yard sun drying. The study suggests that unutilized barns can be converted to dry ripe chillies on a large scale.

Keywords: Chillies, drying, barns and large scale

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1 Introduction

India is the largest producer and exporter of chillies. Large scale drying of chillies is a major problem as the present practice of open yard sun drying leads to poor quality such as colour loss and external contamination. The open yard drying is prone to weather vagaries particularly cyclonic storms due to prolonged exposure i.e. about 15 to 20 days in an open yard. Drying using hot air in an enclosed environment can alleviate the above mentioned problems. Although there are studies on small or laboratory scale drying of chillies (Mishra, 1972; Singh & Alam, 1982; Shivhare et al. 1983; Joy et al. 2001; Mangaraj et al. 2001; Wesley et al. 2002), large scale drying studies using chillies are limited. Ripe chilli pods have low bulk density and offer considerable resistance to heat and mass transfer due to the thick pericarp particularly hybrids (Satyanarayana et al., 2004). Ripe chillies usually have initial moisture content as high as 300% to 400% (db). The moisture content has to be reduced to 8% to 11% (db) for safe storage. Average chilli farmers require dryer of at least one ton/batch input capacity to dry pods from each picking. The drying becomes more challenging when hybrids with thick pericarp and high initial moisture have to be dried on a large scale (i.e. capacities ≥ 1 ton/batch).

At present there are two approaches to tackle this problem. One possibility is the development of a large scale batch dryer that uses LPG or diesel as fuel and these dryers must preferably be mobile for easy transportation from one field to another. The other possibility is the use of existing and unutilized tobacco barns that are available in traditional tobacco growing areas particularly in parts of Andhra Pradesh and Karnataka. There are currently about 5,000 unutilised barns in Andhra Pradesh alone. These barns have been unutilized due to decline in tobacco crop. Interestingly the tobacco crop in these areas is replaced mostly by chilli. Hence, a study is

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undertaken to dry ripe chillies in tobacco barns to overcome post harvest quality related issues in chilli. The main objective of the present study is to establish drying temperature-time schedules and ventilator opening regimes to dry both hybrids and varieties in tobacco barns.

2 Materials and methods

2.1 Construction details of the existing tobacco barns

Major components of tobacco barn are 1) Lean to type roof building, roof is usually made of G.I sheet. 2) Super structure is usually made of masonry brick. 3) Furnace with bricks or permanent cement bricks. 4) Flue pipes and 5) Ventilators (Figure 1, 2, 3 and 4). Either coal or fire wood is burnt in the furnace to generate flue gases. The flue pipes indirectly heat the air and hot air is circulated within the barn by natural convection. Five full and two extra small span tiers (at the top of the roof) exist in tobacco barn. The tiers start from a height of about 1.5 m from the ground and rise up to the roof. The vertical spacing between tiers is about 0.60 m. Tobacco leaves are usually tied in bunches and hung on the bamboos placed in each tier. The capacity normally varies from 15 to 20 quintal green leaf for a room size of 4.8 m×6 m. Barn sizes 4.8 m×6 m, 4.2 m×6 m and 4.8 m×4.8 m usually have two and one furnace respectively. Single furnace type is more popular. However two furnace types are used for better heat control and heavy crop loads. Furnace could be permanent type, usually of cement bricks or "natu" type usually constructed with clay bricks. Natu type furnace needs yearly maintenance.

Usually green tobacco leaf at an initial moisture content, 233% (db) is ripened in an airtight environment of barn at about 35℃ for two days. At the turn of the leaf into yellow color, barn would be partly ventilated using bottom and top ventilators with fresh air. This process is called curing. Curing is followed by drying which is performed by gradually increasing the hot air temperature in steps of 35, 40, 45, 55, 65℃ and finally in some cases to 71℃ to get midrib of the leaf dried. Systematic opening and closing of ventilators and control of feed rate of fuel in the furnace are used to regulate drying air temperature inside the barns. At the final stage, air movement is usually stopped. Generally drying lasts about five days excluding two days of ripening (yellowing/curing). The final moisture in the dried tobacco leaves is usually about 11.1% (db).

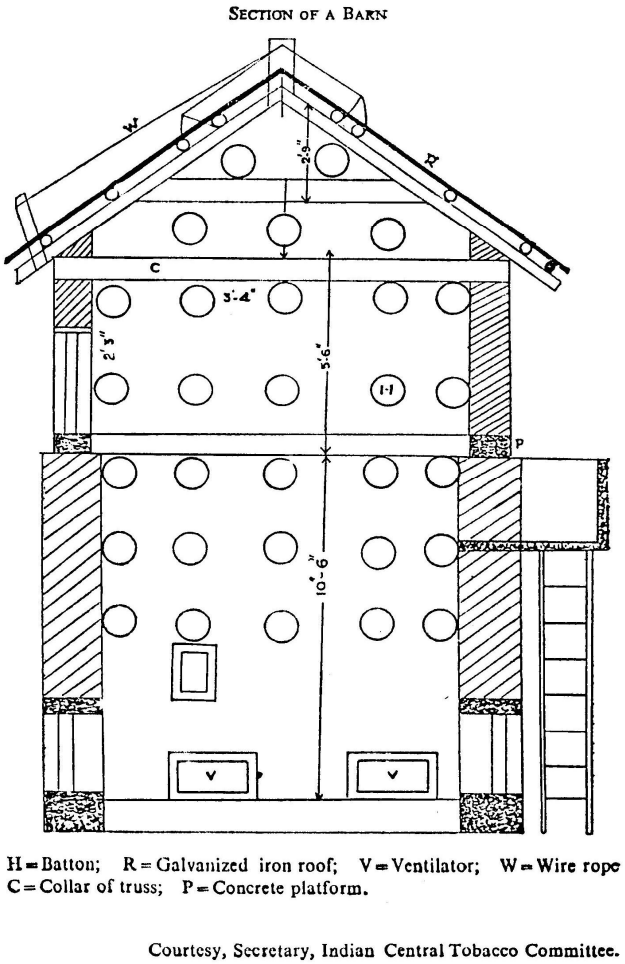


Figure 1 Side view of a tobacco barn

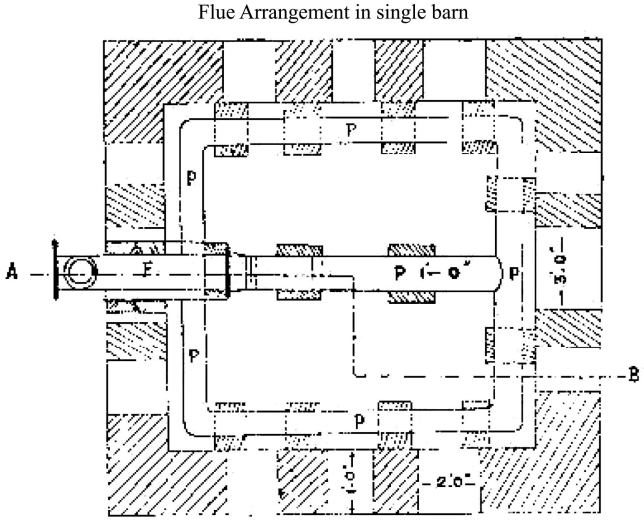
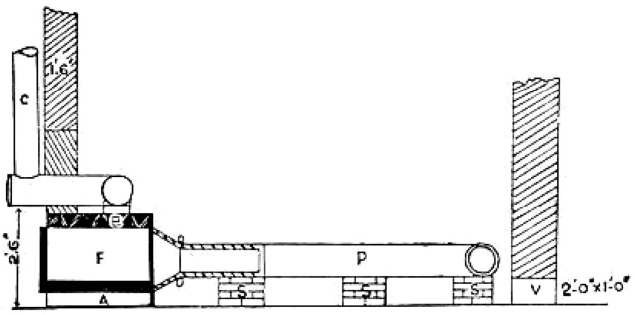


Figure 2 Hot air distribution system in the barn (inside plan view)



F=Furnace; P=Flue; V=Ventilator; C=Chimney; A=Ash pit; S=Masonry support for flue

Figure 3 Furnace and hot air flow line in barn

Figure 4 A view of tobacco barn

2.2 Determination of moisture content, oleoresin, colour value and aflatoxin

Moisture content of chillies is determined as per AOAC method. Estimation of Essential Oils Association (EOA) colour value, percentage of oleoresin was performed as per procedure outlined by Roserbrook (1968). The aflatoxin B1 content was determined using ELISA method. Discoloured pods were separated out in both barns dried and farmers' method and percentage of white pods during drying was calculated.

2.3 Experimental procedure

Freshly harvested ripe chillies of variety LCA 334 (ANGR Agril. University variety) and hybrid INDAM 5 (Indo American seeds Pvt. Ltd) were obtained from local farmers near Guntur in Andhra Pradesh. Separate experiments were conducted using two different types of chillies. A single furnace barn of size 6 m×3.6 m was used in the investigation. Ripe pods were simultaneously dried in the open yard (farmers method) for comparison. Series of experiments using ripe pods with a loading capacity ranging from 1,000 to 1,050 kg were conducted. Ripe chillies were spread into 100 to 110 trays with a loading density of 5 kg per tray. The average thickness of ripe chillies in the tray was 6.25 cm. Galvanized iron wire mesh trays of size 105 cm×75 cm×7.5 cm were fabricated by welding 3 numbers G.I. wire mesh to the frame made of 12 mm M.S flat. Four handles at the length of 15 cm were welded at four corners of the tray for easy handling as well as to place on the existing tiers (Figure 5). Temperature and relative humidity were recorded using online sensors.

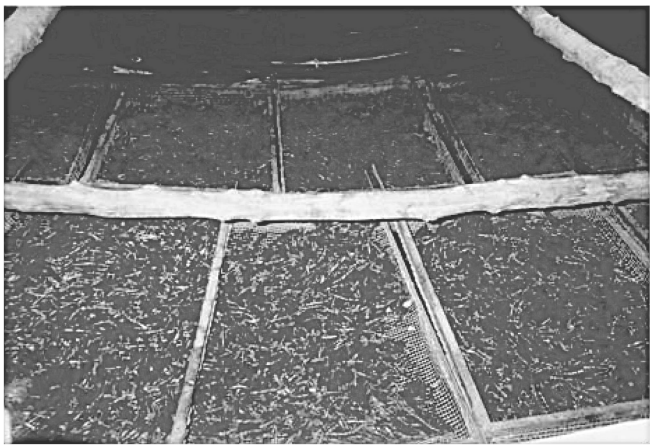


Figure 5 Placement of trays on tiers

3 Results and discussion

Experiments were conducted using two different types of chillies viz local popular variety with thin pericarp (LCA 334) and hybrid with thick pericarp (INDAM 5). The results of the experiment are summarized in Table 1. Moisture content of ripe chillies was reduced from 285% to 300% (db) to 8.7% to 10.5% (db). The drying time varied significantly from 24 hours to 40 hours depending upon whether the chillies is thin pericarp type variety (thin walled chilli) or thick pericarp (thick walled) type hybrid. Drying air temperature was maintained in the range of 50-55℃. It was observed that operation of ventilators both at the top and bottom was crucial to facilitate movement of air as well as to regulate the drying air temperature in the barn. Drying time was 12 to 17 days in farmers' method depending upon whether chilli was variety or hybrid. Based on series of experiments, two different time temperature

regimes were optimized to dry varieties and hybrids (Tables 2 & 3).

Table 1 Summary of experimental results of barn and open yard sun drying of chillies

Parameter method of drying	Value			
	Barn drying		Open yard sun drying	
Hybrid/Variety	INDAM 5	LCA-334	INDAM 5	LCA-334
Initial Moisture content (dry basis%)/%	300	285	300	285
Final Moisture content (dry basis%)/%	9.8	8.7	10.5	9.3
Drying temperature/℃	50-54	51-55	-	-
Drying time	40 hrs	24 hrs	17 days	12 days
Discolored pods/%	3.5	4	14	12
Oleoresin/%	8.47	11.23	8.25	11.34
EOA colour value	27162	16110	20217	12017
Aflatoxin (ppb/kg pod)	<0.5	<0.5	27	21

Table 2 Time, Temperature and ventilator opening regimes to dry chillies (varieties) in barns

Time /h	Temperature regimes /℃	Ventilator regimes	
		Bottom ventilators	Top ventilator
0-4	51	Full closed	Full closed
4-18	53	Half open	Full open
18-24	55	Full open	Full closed

Table 3 Time, Temperature and ventilator opening regimes to dry chillies (hybrids) in barns

Time /h	Temperature regimes /℃	Ventilator regimes	
		Bottom ventilators	Top ventilator
0-4	50	Full closed	Full closed
4-36	52	Half open	Full open
36-40	54	Full open	Full closed

The colour value of hybrid chillies in EOA units was found to be 27,162 in case of barn dried produce in comparison to the colour value of 20,217 obtained by open yard sun drying (farmers' method). Similarly the EOA colour value of varieties was found to be 16,110 in case of barn dried produce in comparison to the colour value of 12,017 obtained by open yard sun drying (farmers' method). Improvement in colour retention of chillies in hot air drying was reported by Lease and Lease, (1962); Joy et al. (2001) and Wesley et al. (2002). Thus the colour retention was higher in barn dried produce. The glossiness and luster of barn dried chillies was also observed to be better than pods dried in farmers' method. The percentage discoloured pods were found to be 3.5% to 4% in barn dried produce compared with 12% to 14% in open yard sun drying. This was of significant economic value on the recovery of final dried chilli. The oleoresin content was almost same in samples dried by both the methods (Table 1). The aflatoxin data indicated that the produce obtained by barn drying method contains only <0.5 ppb of aflatoxin (B_1) in comparison to 21 to 27 ppb in open yard sun dried produce. Low level of aflatoxin in barn dried produce was a major quality improvement suggesting that barn drying can be a good alternative to open yard sun drying of chillies.

It is possible to decrease drying time further if suitable forced air circulation system is provided within the barn. However there is a limitation to this as there is no guaranteed power supply in these areas where barns are located. There is a scope for further research to improve thermal efficiency of these barns by providing insulation and improving the design of flue pipes for improved heat transfer.

4 Conclusions

The present work allows establishing some important conclusions, namely:

1) Ripe chillies can be dried in the existing tobacco barns by spreading chillies on G.I.wire mesh trays of size 105 cm×75 cm×7.5 cm placed on different tiers of the barn. Loading capacity of 6 m×3.6 m size barn is ten quintals of ripe chillies.

2) Drying time in barns varies considerably depending upon whether the pods are thin pericarp type varieties (thin walled chilli) or thick pericarp type hybrids (thick walled hybrids). The hybrids take about 40 hours whereas the varieties take about 24 hours to reduce moisture content of chillies from 292.5% to 9.6% (db). However open yard method takes 12 to 17 days respectively for hybrids and varieties leading to loss of time and poor quality in traditional method.

3) Time, temperature and ventilator operation regimes are important to get good quality uniform dried produce. The operation schedules of bottom and top ventilators vary considerably to dry hybrids and varieties.

4) The colour retention of barn dried chillies is higher

in comparison to the chillies dried in open yard sun drying (farmers' method).

5) The percentage discoloured pods are only 3.5% to 4% in barn dried produce compared with 12% to 14% in open yard sun drying thus the barn drying method gives higher recovery of final dried produce.

6) Aflatoxin (B1) content of barn dried samples is <0.5 ppb in comparison to 21 to 27 ppb in open yard sun dried produce thus improving final quality.

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