Madras Agric. J. 88 (1-3) : 7-12 January - March 2001
https://doi.org/10.29321/MAJ.10.A00290

Performance evaluation of solar dryers in drying vermicelli

V.J.F. KUMAR AND C. DIVAKAR DURAIRAJ
College of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu

Abstract : Step type and cabinet solar dryers were used for drying vermicelli in cottage industry. Initially laboratory studies were undertaken to dry the vermicelli in an electric hot air oven to find out the optimum hot air temperature, yielding the best product quality. The time required for drying vermicelli at five temperature namely 40, 50, 60, 70 and 80° C were determined along with the quantity of dried broken vermicelli less than 25 mm length, to analyze the quality. Vermicelli of 0.7 mm diameter, dried at 55 to 60°C yielded 21±1 per cent broken. Another laboratory study was conducted on step type and cabinet dryers to record the stagnant temperatures for 0, 25, 33, 50 and 100 per cent opening area of ventilation outlet. Based on the study, the air outlet opening area was optimized to maintain 55 to 60° C temperature inside the dryers. The dryers were then installed in a cottage industry and the product was dried maintaining the optimized temperature. The time taken to dry a batch of vermicelli from 24 to 6 per cent moisture on a sunny day was 120 min in the dryers, compared to 315 min in open air. The drying time observed on the dryers during cloudy day was 180 min as compared to 420 min in sun drying with thin layer of spreading. The rehydration studies on the dried products from all the treatments indicated 200±10 per cent water absorption within 20 min using 50° C hot water.
(Key words : Vermicelli, Solar drying, Cabinet dryer, Step type dryer, Rehydration, Drying temperature.)

Solar energy is mainly used for drying agricultural produces in India, because solar radiation is abundantly available at an intensity of 5 of 7 kWm^{-2}. Usually open yard drying is practiced which is unhygienic. Here the drying temperature could not be controlled to our requirement, which results in poor quality of dried product. To dry agricultural produces quickly and hygienically, different types of solar dryers are used. These dryers can raise stagnation temperature 10 to 20°C above ambient temperature and a reduction of relative humidity by 60 per cent, which is quite adequate for drying most of the products to the level of safe moisture content.

Kapoor and Agrawal (1975) dried peaches, peas and cauliflower in a solar cabinet dryer in a temperature range of 66 to 77°C in 2.5 to 18 h. Singh and Alam (1985) rationalized the design of different components of a solar cabinet dryer, incorporating a wind aspirator and tested it for drying potato chips, spinach and mint. Kumar *et al.* (1998) developed a solar cabinet dryer of 2 m^2 collector area to dry agricultural products. Copra pieces of 40 to 60 mm size were dried from 46 to 5 per cent moisture in 8 h. Cassava chips of 5 to 7 mm thick took 8 h to dry from 62 to 5 per cent moisture. Red chillies with 68 per cent moisture were dried to 15 per cent in 5 h.

Solar dryers are therefore useful in food industry. Presently, cottage industries dry vermicelli un-hygienically in open yards. Solar dryer is a cheap alternative for drying such food products. Hence an attempt was made to adopt cabinet and step type solar dryers to dry vermicelli, after undertaking preliminary laboratory studies to optimize the drying temperature yielding the best quality.

Materials and Methods

Laboratory studies on vermicelli and its drying

Since basic data on drying of vermicelli are not available towards assessing the quality of vermicelli drying, preliminary investigations on different aspects of the product, its drying behaviour and resulting quality were conducted in the laboratory.

a.Size of vermicelli

Ten samples of extruded and steamed vermicelli were collected from a cottage industry and their diameter were measured using ocular microscope. Subsequently the steamed samples were dried at a controlled temperature of 55-60° C from 24 to 6 per cent moisture in an electric oven for about 90 minutes and the diameter was measured. This provided the data for assessing the optimal dried product size.

b.Drying studies

Laboratory study was undertaken to dry the vermicelli in an electric hot air oven to find out the optimum hot air temperature required for getting the best quality of vermicelli. Five temperature *viz.* 40, 50, 60, 70 and 80° C were selected to dry 250 g of steamed product. The time required for drying

and the broken which is less than 25 mm in length in the dried sample were observed to analyze the quality of vermicelli.

c.Quality assessment of dried vermicelli

Quality of vermicelli dried in the laboratory was analyzed based on the broken obtained and rehydration characteristics. The weight of broken which are less than 25 mm length in one and half kg of dried vermicelli was observed and percentage of broken was calculated. More the percentage of broken, less is the quality. Similarly the rehydration characteristic of 500 g of dried vermicelli of each sample was observed by immersing it in 50°C hot water for 20 minutes. The quantity of water absorbed was measured. More the water absorbed, the rehydration quality of product is higher.

Adoption studies of the dryers

Two types of solar dryer were selected for drying vermicelli. The description of the dryers are explained below.

a.Step type dryer

The step type solar dryer consists of an absorber made of 20 SWG galvanized iron sheet black painted at the top and insulated with 100 mm thick glass wool at the bottom. The dryer (Fig.1) is covered at the top with a layer of 3 mm thick plain glass. The side frames are made of 19 mm thick plywood. At the rear side of the collector, two chimneys of 150 mm diameter each and 1200 mm height with butterfly valve are fixed to control the air flow rate. Two holes of 100 x 100 mm are provided at the bottom of the collector just below the first step to allow fresh air into the dryer. The unit holds 10 aluminium trays of 8650 x 4000 x 500 mm size. The trays are perforated to allow hot air through the product to be dried. The solar dryer has an inclination of 10 deg to the horizontal.

b.Cabinet dryer

A solar cabinet dryers of $3m^2$ area (Fig.2) consists of a space for collecting solar energy and drying the product. It has a rectangular insulated box with absorption plates covered with a layer of 4 mm transparent glass. The angle of the roof cover is kept as 11 deg. The frame work of the unit is contructed using plywood. The bottom panel is insulated with glass wool to a thickness of 100 mm. The interior of the cabinet is painted black. Holes are provided in the bottom panel to allow ventilation of the evaporated moisture by natural convention. Two aluminium perforated trays of 1050 x 1050 x 60 mm are used to keep the materials spread evenly in the dryer. A chimney of 150 mm dia with butterfly valve is fixed to the unit to regulate the air flow rate.

Laboratory studies on the temperature characteristics of the selected dryers.

The selected driers being natural convection type, have temperature characteristics mainly influenced by the solar intensity in the given day and the air flow rate as caused by the natural convection through the dryer. Hence a study was conducted to record the hot air temperature inside the step type and cabinet dryers for various openings of the butterfly valve in the chimney. The butterfly valve opening was kept at 0, 25, 33, 50 and 100 per cent positions on subsequent days of the month to observe the hot air temperature obtained inside the dryers. The hot air temperature in the step type dryer was measured at the top and bottom in two places and average worked out. In cabinet dryer the temperature was measured in two locations and averaged. The ambient temperature and solar intensity was also recorded simultaneously.

Performance of the dryers in cottage industry

The selected dryers were installed in a private vermicelli manufacturing industry. They were intensively evaluated for drying vermicelli. The tests were conducted during the month of August and September. The solar intensity, ambient temperature and temperature of hot air inside the dryers were recorded after every half an hour. The moisture content of the dried vermicelli in stem type and cabinet dryer and sun dried samples were also observed. The time required to dry a batch of vermicelli was recorded. Quality of the dried vermicelli was also assessed.

Results and Discussion

Size of vermicelli

It was observed that the average diameter of extruded, steamed and dried vermicelli were 7.04, 7.06 and 6.05×10^{-1} mm respectively (Table 1). There was no variation in the diameter of extruded and steamed vermicelli. During drying due to the reduction of moisture content, the diameter of vermicelli was reduced by 0.1 mm.

Laboratory studies on vermicelli drying

The time required for drying vermicelli from 24.5 to 6 per cent (w.b.) and the percentage broken observed in hot air oven method are summarized in

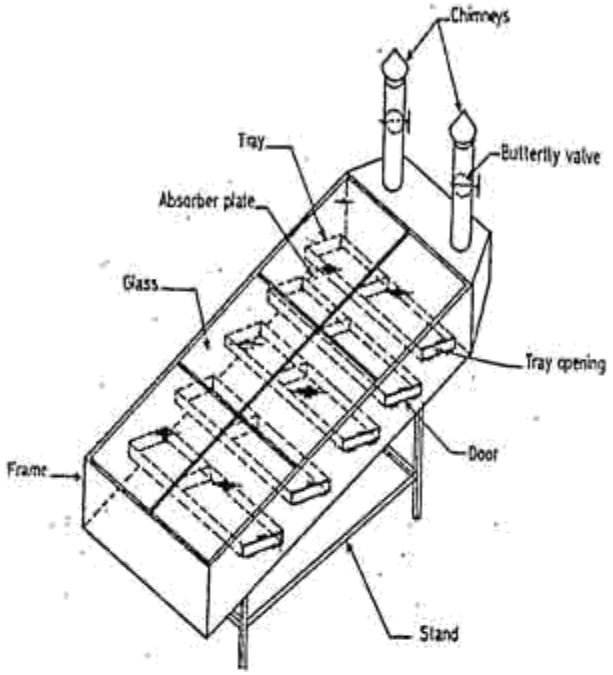

Fig.1 Solar Step type drier

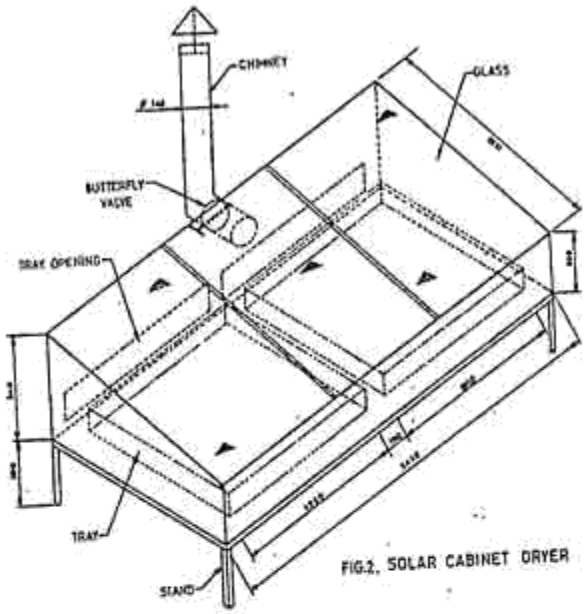

Fig.2 Solar Cabiner Dryer

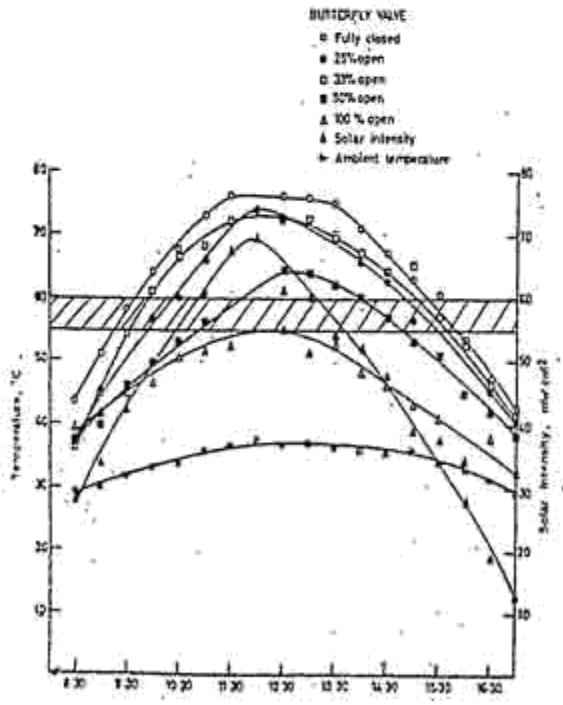

Fig.3 Influence of valve opening onhot air temperatue in Cabinet Dryer

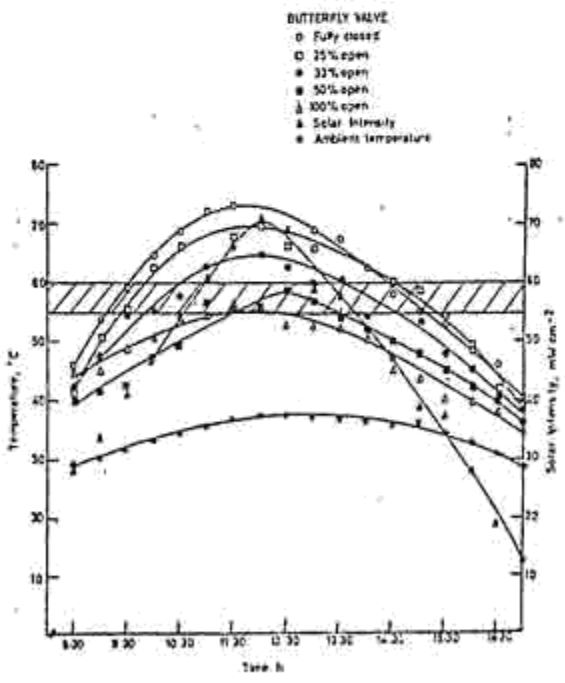

Fig.4 Influence of valve opening on hot air temperature in step type dryer

Table 1. Size of vermicelli

Vermicelli	Diameter, mm x 10^{-1}										Average
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
Extruded	7.1	7.0	6.8	7.2	7.1	7.0	7.3	6.9	7.0	7.0	7.04
Steamed	6.9	7.3	7.4	7.0	6.9	7.2	7.0	7.0	7.1	6.8	7.06
Dried	6.1	6.3	5.8	6.1	6.0	6.0	5.9	6.1	6.0	6.2	6.05

Table 2 Quality of vermicelli at various drying temperatures

Temperature °C	Drying time min	Broken %
40	150	18.5
50	112	20.0
60	81	23.1
70	72	28.5
80	63	31.2
Sun Drying	290	21.2

Table 3. Valve position for step type dryer

Time, h	Valve position
9.00 - 9.30	Fully closed
9.30 - 10.00	67% closed
10.00 - 11.00	75% closed
11.00 - 11.30	100% closed
11.30 - 13.30	50% closed
13.30 - 14.30	75% closed
14.30 - 15.30	67% closed
Total time :	390 min

Table 4. Valve position for Cabinet dryer

Time, h	Valve position
9.15 - 9.30	Fully closed
9.30 - 10.00	67% closed
10.00 - 10.30	75% closed
10.30 - 11.30	50% closed
11.30 - 13.00	100% opened
13.00 - 15.00	60% closed
15.00 - 15.30	75% closed
15.30 - 15.45	100% closed
Total time :	390 min

Table 2. The time required to dry the vermicelli in direct sunshine was 290 min. In electric oven, increase in temperature from 40°C to 50°C reduced the drying time by 25 percent. At 60°C, the time required for drying was reduced by 46 per cent as compared to 40°C. The percentage of broken obtained inferred that it is directly proportional to drying temperature. Though the temperature of sun drying is lower than drying in hot air oven, the broken recorded was 5.6 and 12.7 per cent higher in sun drying than 40 and 50°C. This may be due to handling of the vermicelli to put it upside down for effective drying twice in sun drying. These studies concluded that drying the vermicelli at 55-60 °C will result in an approximately equivalent quality to that of sun drying, besides reducing the drying time.

The studies on rehydration of dried vermicelli at 55 - 60°C showed that 200± 10 percent water absorption was present within 20 minutes using 50°C hot water. This rehydration characteristic of the dried product, was found to be satisfactory.

Table 5. Performance of solar dryers in drying vermicelli (Sunny day)

Time	Solar intensity	Ambient temp.	Temp. in cabiner dryer	Temp. in step dryer		
				Top	Bottom	Average
h	$mWcm^{-2}$	^0C	^0C	^0C	^0C	^0C
9.00	50.30	33.20	51.50	53.30	48.10	50.70
9.30	40.37	30.10	56.30	58.20	54.40	56.30
10.00	78.80	34.40	61.20	65.80	58.20	62.00
10.30	78.85	37.30	58.40	67.30	57.10	62.20
11.00	92.67	37.50	62.20	66.40	60.60	63.50
11.30	98.50	38.30		Unloading and Loading		
12.00	80.33	37.80	61.10	65.10	60.30	62.70
12.30	77.20	36.50	62.40	63.20	58.40	60.80
13.00	75.40	36.40	58.30	60.10	54.10	57.10
13.30	74.30	35.50	60.50	61.50	55.50	58.50
14.00	67.70	34.70	59.40	59.30	54.60	56.90

Table 6. Performance of solar dryers in drying vermicelli (Cloudy day)

Time	Solar intensity	Ambient temp.	Temp. in cabiner dryer	Temp. in step dryer		
				Top	Bottom	Average
h	$mWcm^{-2}$	^0C	^0C	^0C	^0C	^0C
10.00	12.33	30.50	35.30	37.50	35.30	36.40
10.30	Rain	25.30	38.20	34.20	33.80	34.00
11.00	72.67	30.20	41.70	42.20	44.10	43.15
11.30	66.33	33.40	48.80	56.30	55.40	55.35
12.00	72.00	35.60	56.40	61.20	57.40	59.30
12.30	82.67	37.30	53.50	65.40	63.20	64.30
13.00	70.33	37.10	60.80			

Laboratory studies on temperature characteristics

Solar intensity, ambient temperature and the average temperature observed in the step and cabinet dryers for different opening areas of the butterfly valve, with respect to time are illustrated in figures 3, 4. From the plots, information on the position of butterfly valve to obtain a 55 - 60°C hot air temperature at different times of the day was derived (Table 3, 4). From the tables, it was ascertained that in step type and cabinet dryer 55 - 60°C hot air temperature could be obtained for 390 minutes by manipulating the butterfly valve position.

Vermicelli drying in the industry

In both the dryers 15 kg of vermicelli was loaded in the trays to a thickness of 50 mm. The experiment was started at 9.00 am and the bulk of vermicelli was inverted after an hour. The drying temperature was monitored and adjusted to remain at 55 - 60°C range by manipulating the butterfly valve opening, as ascertained in the laboratory study. The product was unloaded and the next batch was loaded after complete drying. The average temperatures observed in the dryers for sunny and cloudy days are shown in Table 5, 6 respectively. From the results,

it was observed that the laboratory predictions agreed well with the field conditions. The average temperatures were well within the range of 55 - 62° C on the sunny day (Table 5) The slight overshoot may be due to the variations in solar intensity of the particular day. It was also inferred that only two batches of vermicelli could be dried in a day. The time taken to dry a batch of vermicelli in a sunny day was 120 minutes in both the dryers whereas it was 315 minutes in the open yard. The drying time observed using the dryers during cloudy day was 180 minutes as against 420 minutes in open yard drying.

References

Kapoor, S.G. and Agrawal, H.D. (1975). Solar dryer for Indian conditions. *International Congress on the Sun in the service of mankind, Paris. 29.*

Kumar, V.J.F., Divaker Durairaj, C. and Sampathrajan, A. (1998). Solar cabinet dryer for perishables and cereals. *Madras Agric. J.* 85 : 572-577.

Singh, H. and Alam, A. (1985). Design of prime mover-less solar dehydrator. *J. Agric. Engng. ISAE.* 22 : 35-41.

(Received : April 2001 ; Revised : June 2001)

Madras Agric. J. 88 (1-3) : 12-16 January - March 2001

Effect of time of sowing and weed management practices in semi dry rice

V. SELVAM., S.N.M. RAMACHANDRA BOOPATHI., AL. NARAYANAN AND R. POONGUZHALAN

Dept. of Agronomy, Pandit Jawaharlal Nehru College of Agric. and Res. Institute, Karaikal-609 603. Pondicherry.

Abstract: Field experiments were conducted at Agricultural College and Research Institute, Madurai, to study the effect of time of sowing along with weed management practices in semidry rice. The treatments included sowing practices such as pre monsoon sowing (one week ahead), pre monsoon sowing (two weeks ahead), sowing immediately after onset of monsoon, in mainplots and herbicide such as pendimethalin, pretilachlor, pretilachlor + safener, in sub plots. No significant difference was noticed among various sowing practices in the main plot. Among the herbicides, pendimethalin recorded the highest grain yield and was on par with pretilachlor + safener at 8 DAR. *(Key Words: Semidry rice, Pendimethalin, Pretilachlor, DAR) (Days After Rainfall)*

Rice is the principal crop of densely populated tropical Asia and is cultivated under varied ecosystems. In India, though rice is predominantly grown in lowland condition, 8 m ha are raised under upland condition. Semidry rice is characterized by sowing dry seed of rice with the help of monsoon rain and subsequently converted to wet condition by using tank or canal water. Under constraints of delayed release of irrigation water, semidry rice is now recommended to the rice growing farmers of Tamil Nadu.

The success of semidry rice mainly depends on time of sowing and weed management practice which accounts for 23.0 and 17.2 per cent of yield respectively (Singh et al. 1990). The effective utilization of the first monsoon rain is made possible by pre monsoon sowing for good germination and seedling establishment. The relative efficiency of pre and post monsoon sowing need to be evaluated to identify the suitable time of sowing for semidry rice.

Weeds pose severe problems in semidry rice, in the early stages of growth. The yield loss, as high as 89 per cent was reported by Sarkar and Moody (1981). This necessitates an effective weed management practice to control weeds in semidry rice. Though the conventional method of hand weeding is widely practiced, herbicides are considered to be more efficient for timely control of weeds.

Though a good deal of information is available on weed management in transplanted rice, information on optimum time of sowing and efficient weed management practices in semidry rice is not much. Keeping this in mind, a study on the optimum time of sowing coupled with weed management practice for semidry rice was conducted.

Materials and Methods

The experiment was conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai during September 1992 to January 1993.The soil was sandy clay loam in texture and was low in available N (218.4 kg ha