Design, Development and Testing of a Batch Type Solar Copra Dryer

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ABSTRACT

Solar Copra dryer for capacity of 150 coconuts per batch was designed developed and tested. It saved 44 per cent of total drying time, in bringing down the moisture content of Kernel from 53.10 per cent (w.b.) to 6.2 per cent (w.b.), compared to open yard drying. The drying cost per 100 nuts was Rs. 3.45 for solar dryer as against Rs. 6.67 for open drying.

INTRODUCTION

The fresh coconut kernal has to be dried from about 55 per cent to 6-7 per cent moisture content for it's use as copra. Rate of moisturer e-moval during drying is a critical quality factor. Too slow rate allows the kernal to develop mould whereas too rapid continuous drying lowers the quality of copra by alerting it's physical, nutritional and chemical properties.

Drying of coconut kernal in sun has been the practice from historical past and traditional coconut growing tracts are also blessed with plenti-ful of solar energy. Most of the villages, being widely dispersed, do not have conventional sources of energy (electricity/fossil fuels) which could be utilized for coconut drying.

Many research workers have recommended that the coconut kernal drying temperature should not exceed 70°C which is well within the reach of flat plate type solar collector[6]. Inview of the energy crisis, the efficient use of solar energy for drying the coconut kernel may be useful and economic. Therefore, an attempt was made to develop solar copra dryer.

REVIEW OF LITERATURE

In Surinam, kernel is dried on the simple and cheap racks made of bamboo[1]. Racks are to be either covered or carried inside the room during rains. Also, extra labour is needed for the care of nuts from rains, rodents and birds etc. Use of solar energy for drying of agricultural pro-ducts is increasing[2,4,6]. In these systems the artificial air flow through the solar collector has been advocated. However, at Lisboa and Brazil, natural ventillation from a chimney combined with flat plate solar collec-

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tor gave encouraging results for drying of figs[1]. Danials suggested the need for further research on effective utilization of thermal chimneys[5].

In India coconut meat is dried either in open yard or in smoke kiln or sun drying combind with smoke kiln drying. The copra, thus produced, not found to be of good quality. It is generally contaminated by micro organisms, dirt, dust and smoke etc[6].

MATERIALS AND METHODS

Dryer designs

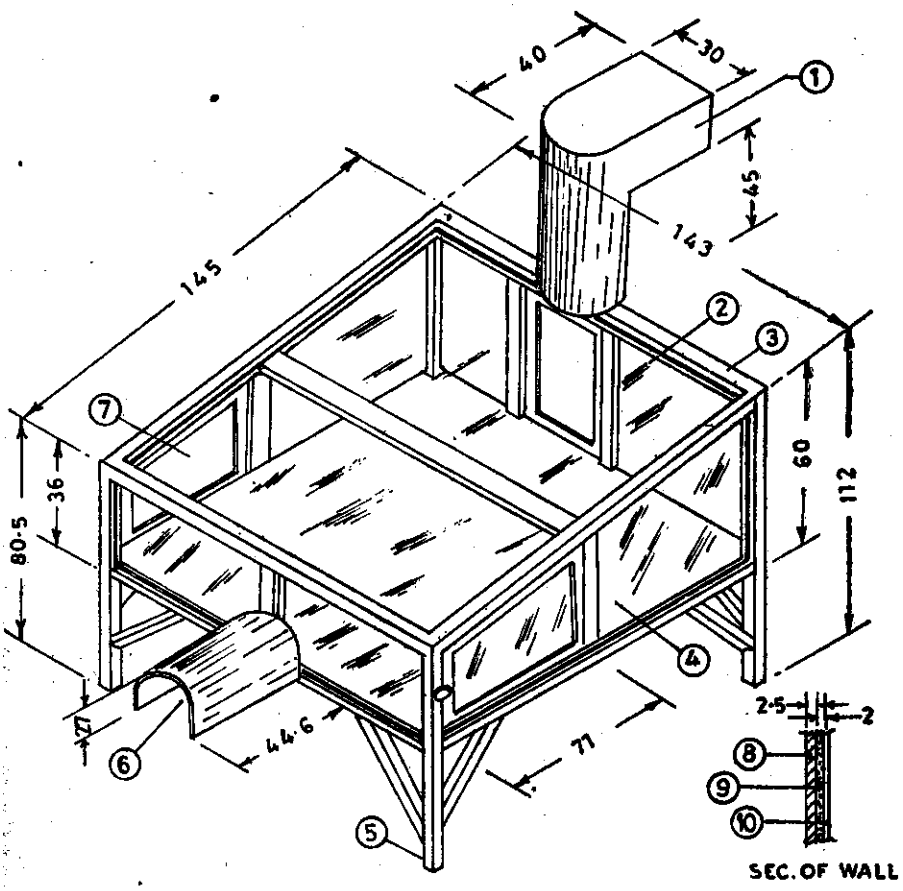
The dryer was designed for keeping 300 halves of 150 nuts at 55 per cent moisture content (w.b.) in single layer. Assumptions for the design were: average weight of copra per nut: 160g, temperature of flat plate collector: 65°C, shape of collector: Square, drying temperature inside the dryer: 55°C, temperature of exhaust air: 38°C, temperature of inlet air 30°C, angle of inclination (angle of latitude of place): 12.5°, efficiency of collector: 50%, intensity of radiation; 730 Kcal/hr/m^2, latent heat of vaporization: 600 Kcal/kg., average sunshine hours per day: 8 number of days for drying: 5, moisture removal from 55 per cent to 5 per cent (w.b.). With these asumptions, the demensions of the collector worked out to 1.45m×1.45m and thickness of insulation worked out to 1.5-2.0 cm. (Fig.1).

Details of the dryer

A solar copra dryer, made up of saj wood, glass sheet, coconut husk (insulation material) and galvanized iron sheets, was developed (Fig. 1). The drying chamber was made with the saj wood except the two sides and the top cover of 3 mm glass sheets. One and half cm thick layer of coconut husk was put on the wooden planks and then a 22 guage galvanized iron sheet was screwed over it to avoid the heat losses (Fig. 1). Inlet and exhaust were made of galvanized iron sheet and provided with wire mesh. Galvanised iron sheet was painted black for better radiation absorption. The inlet and outlet induce the flow of air and facilitate exit of evaporated moisture. The dryer was supported with four legs. Three gates were provided on three sides of the dryer for putting the coconut meat in and taking the copra out, and for taking observations. The drainage channel was provided at the lower end for draining out the rain water from glass surface.

Operation of the dryer

The solar dryer employees the chimney effect. The plain glass sheet provided on top portion of dryer traps the solar radiation and conserves the heat inside, which is utilized for drying. It works on the principle of faster low grade thermal drying which is a method of reducing moisture content of the kernel over an extended period of time but with the help of solar energy and natural draft of the airflow such that kernel is dried before it's deterioration takes place[8]. Ambient air enters the inlet, get



1 Exhaust, 2 3mm Glass Sheet, 3 Frame, 4 Drying Plateform, 5 Legs, 6 Inlet, 7 Doors, 8 Wooden Plank, 9 Coconut Husk Insulation, 10 G. I. Sheet, 22 Gauge

Fig. 1 Batch Type Solar Copra Dryer

heated up inside the solar chamber, expands and moves upward towards the exhaust.

Test procedure

Nuts were husked, split into two halves and drained free of the nut water. One half of the nut was put in the dryer and other half of the same nut was put in open yard in layer facing the kernel upward for comparative study. The drying continued from 8 AM to 5 PM every day. The nuts were stored in gunny bags during night hours and then spread in the open yard for drying on next day. Five samples, 15 g each, were taken from five places (four corners and centre) and analysed for moisture content, oil content, FFA and protein value by hot air oven, soxhlet apparatus, standard laboratory method and Kjeldhal flask method respectively. The temperature was measured with mercury thermometer at inlet, outlet, copra, centre of the drying chamber and near glass surface. Ambinet temperature and corresponding temperature in the dryer

at 9.30, 11.30, 13.30, and 17.30 hours of different days were recorded and average temperature ambinet relative humidity, sun shine hours and wind velocity are given in table 1.

RESULTS AND DISCUSSION

Copra drying tests (7Nos) with solar copra dryer were conducted and compared with open yard drying. Copra was dried satisfactorily in all the tests conducted in solar dryer. In most of the tests, drying proceeded faster in the solar dryer as compared to open yard drying. The kernels were dried from an average initial moisture content of 53.1(per cent to 6.2 per cent (w.b.) in 5.4 and 9.7 dyas in solar dryer and oper yard respectively. The drying was faster in the begining and slower ir later stage of drying. (Fig. 2). It may be due to the fact that in the begin ning the evaporation is very much similar to the free surface evaporatio but in the later hours of drying the solar heated air has to drive out th moisture from the inner part of the kernel towards the outer surfac which is exposed to the solar heat. It was also observed that the relativ humidity in the dryer decreased from 88 to 42 per cent as the dryin proceeded. But the relative humidity in open yard did not vary muc during complete drying process. It indicates that the relative humidit was lesser in the dryer as compared to out side as the drying proceede due to the fact that dry bulb temperature inside the solar dryer wa higher. The accumulated moisture in vapour form was removed b creation of natural flow of air. The low relative humidity in the air hel in quicker removal of moisture from the meat. The average maximu and minimum temperature inside the dryer were found to be 53.43° and 43.20°C respectively and in open yard 33. 21°C and 26.98°C respe tively. Analysis of the samples indicated that there was slight increase the FFA in the oil obtained from copra dried in open yard. Table 2 giv the variations in oil content, moisture content and protein. The prote value was not affected significantly. The oil output was slightly mo from the copra dried in the solar dryer (Table 2) due to no loss of cop from rodents and birds etc. The batches dried in the solar dryer we found least affected by fungal and pest attack when compared to tho dried in open yard.

Economic considerations

The cost of the dryer worked out to be Rs. 650. Working life of dr was estimated to 10 years. It requires only 3 man-hours for completi the drying of 150 coconuts, as against 10 man-hours for open ya drying. The solar dryer prevents everyday use of labourers for putti the copra in and out of the store room. The quality of copra obtain from solar dryer is better. This dryer is quite cheap in view of it's lc life, simple in design and is easy in operation. Even village carpenters c fabricate it. It's cost can, however, be brought down provided produc on mass scale. Considering the labour charges as Rs. 10 per day,

Table 1 : Measurement of Temperature, Relative humidity and Wind velocity for copra drying in Solar Dryer and open yard

Sl. No.	Date of start	Drying period days S.D.	Drying period days O.Y.	Mean Temperature °C S.D Outside	S.D Inlet	S.D Inside	S.D Exhaust	OY	Mean Ambient RH.% S.D	Mean Ambient RH.% O.Y.	Mean Sunshine hours S.D	Mean Sunshine hours O.Y.	Mean Wind Velocity Kmph S.D.	Mean Wind Velocity Kmph O.Y.	Remarks
1.	10—01—78	5	11	26.703	—	49.293	—	26.983	—	—	—	—	—	—	
2.	07—10—78	6	—	31.682	33.464	43.834	37.962	—	93.88	—	7.98	—	2.76	—	
3.	26—10—78	5	9	32.514	34.800	53.432	46.430	31.586	93.90	84.02	7.60	7.51	2.60	2.77	
4.	06—11—78	6	9	31.088	32.200	47.144	39.298	31.066	83.83	84.41	6.30	6.86	3.06	2.75	
5.	24—11—78	6	11	30.532	32.854	44.104	37.134	31.520	72.83	71.50	7.21	7.68	2.66	2.54	
6.	05—12—78	4	8	33.772	35.200	50.078	41.280	33.212	67.75	66.87	9.57	8.87	2.92	2.87	
7.	27—12—78	6	10	30.658	31.726	43.184	37.314	31.658	76.00	72.80	4.16	6.70	2.73	2.76	

S.D. : Solar Dryer, O.Y.: Open yard

Table 2 : Analysis of dried copra*

Sl. No.	Test No	Mode of drying	Tota drying time [days]	Fresh kernel wt [kg]	Wt. of dried copra [kg]	Analysis of copra				Remarks
						Oil content %	FFA %	Protein value %	Final mc (wb) %	
1.	1	Solar dryer	6	32.50	16.61	68.70	0.113	7.30	6.50	
		Open yard	11	32.00	15.90	67.10	0.169	7.25	6.20	
2.	2	Solar dryer	6	35.00	17.95	69.20	0.110	7.50	7.53	
			—	—	—	—	—	—	—	Unfavourable weather condition
3.	3	Solar dryer	5	36.25	19.13	67.30	0.109	7.25	5.20	
		Open yard	9	34.50	17.68	66.70	0.257	7.20	5.60	
4.	4	Solar dryer	6	34.00	17.32	69.10	0.160	7.20	6.10	
		Open yard	9	33.75	17.15	69.00	0.220	7.20	6.30	
5.	5	Solar dryer	6	39.00	20.32	69.54	0.121	7.30	6.20	
		Open yard	11	41.00	21.05	69.30	0.198	7.32	6.70	
6.	6	Solar dryer	4	40.00	20.65	68.90	0.100	7.10	6.50	
		Open yard	8	39.20	20.00	68.20	0-160	7.10	5.90	
7.	7	Solar dryer	6	40.80	21.73	69.30	0.128	7.40	6.60	
		Open yard	10	40.00	21.25	68.80	0.351	7.38	6.50	

* Composition (in per cent) of coconut by weight was as : husk : 50, shell : 14, Kernel : 26, Water : 10.

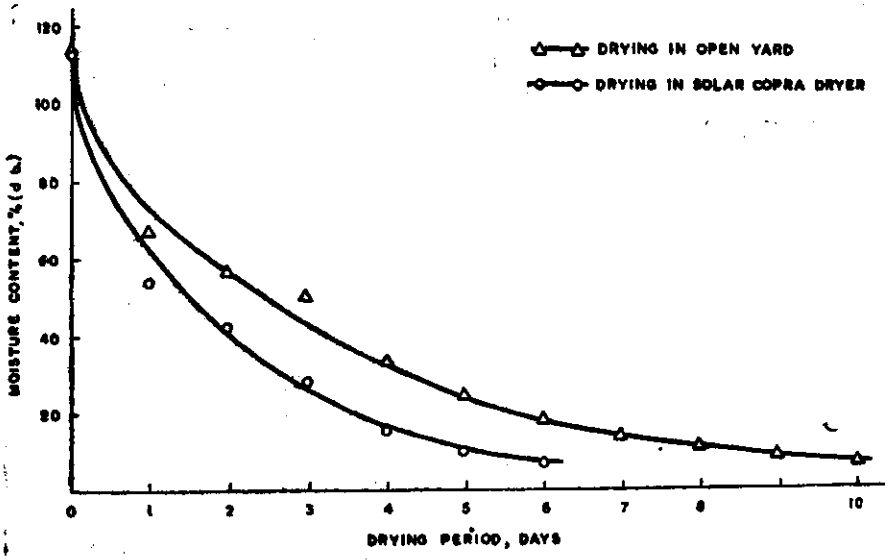


Fig. 2 Drying Curve-Drying VS Moisture Content

drying cost per 100 nuts in solar dryer workedout Rs. 3.45 as against Rs. 6.67 in open yard.

CONCLUSIONS

A batch type solar copra dryer of 150 coconuts capacity was designed developed and tested. It took 5.4 days for drying coconut from 53. 10 to 6.2 per cent moisture level (w.b.) as compared to 9.7 days in open yard. The solar copra dryer costs Rs 650 and could be fabricated by village artisan. It can be popularised among coconut growers.

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