INDIRECT HEATING TYPE COPRA DRYER IN INDIA

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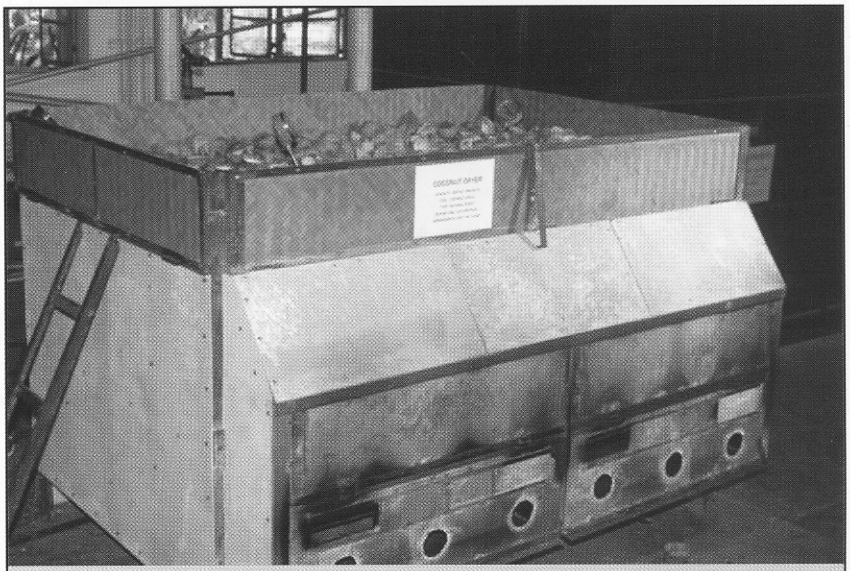
Indian coconut industry is driven by copra/coconut oil markets. Drying is an important post harvest operation in coconut processing for the extraction of oil. Traditional system of copra drying is by spreading the cups (split open coconut) on any open surface for sun drying. It takes about eight days for sun drying of copra. Deposition of dirt and dust on wet meat during sun drying results in deterioration of copra quality. Further, cloudy weather and low atmospheric temperature also reduce the quality of copra. The direct-type kiln dryers are also not desirable for copra making as it becomes inferior in quality due to the smoking and improper drying.



Shell Fired Copra Dryer in India

In India, coconut is broken transversely into two cups and is then generally sun-dried. About seven days are needed to reduce the moisture content to 5 -6% from the initial 45 - 55% in order to reduce the weight, prevent microbial deterioration and concentrate oil. During rainy season, when conventional practice of sun drying is not possible, drying by artificial method is the only possible solution for processing the produce (Annamalai, 1989). The existing direct type kiln dryers are also not desirable as the product become inferior in quality due to smoking and improper drying. Copra which has been smoke dried using coconut husk or wood is often more highly contaminated with PAH than that dried using coconut shell. Hence, most copra produced is relatively of poor quality, principally caused by inadequate drying techniques. The common quality defects are:

- high free fatty acid (FFA) content
- extensive fungal contamination, notably by *Aspergillus spp.* which may produce carcinogenic aflatoxins
- high poly cyclic aromatic hydrocarbon (PAH) content particularly in directly smoke dried copra (Drew, 1992)

Aflatoxins are produced due to inadequate or lengthy drying. Smoke contamination can be avoided by using heat exchangers to heat the drying air indirectly .Coconut oil and copra cake thus produced can contain unacceptably high levels of aflatoxin. At present, the copra industry is beset with quality and technical problems that resulted to very low prices of copra-related products in the world market. Quality problems include the contamination by aflatoxins in copra and copra cake, a cancer-causing toxic metabolite produced by the *Aspergillus* sp. group of moulds, specifically *Aspergillus flavus,* the presence of high contents of free fatty acid (FFA) that increases the refining cost and reduces the oil recovery by 1.4 times The aflatoxins and FFA problems are attributed to the high moisture content of copra after drying and during storage while PAH-related problems are due to direct contamination with smoke during copra drying. Many of these difficulties stemmed from technical problems of inappropriate drying conditions and poor dryer design. Hence a new type of copra dryer was developed which is tested in the farmer's field also. The dryer parameters like size of the drying chamber, size of burner, shape of heat exchanger, ventilation holes etc. have been designed taking into consideration, various factors like bulk density, psychrometric and heat transfer principles. This dryer uses only coconut shell, as fuel and no other fuel can be used. The dryer is designed to hold 1000 - 1500 coconuts depending on the size of the nuts. The developed dryer is shown in Plate 1.

The dryer consists of a drying chamber, a unique burning chamber, a heat exchanger and ventilation holes. This dryer was fabricated using locally available materials such as bamboo sheet,

Shell fired copra dryer being demonstrated at Banam, Kasaragod district, India

Galvanized iron sheet, Mild Steel angle and fire resistant plywood. The contact areas (sides) with copra are provided with heat resistant plywood. The overall dimensions of the dismantling type rectangular frame were 2.25 (L) x 1.5 (B) and 1.5 m (H) using 40 × 40 × 3 mm equal angle iron and 20 x 5 mm mild steel flat as supporting frame. The dryer fabricated is shown in Plates 5 and 6. The rectangular structural frame was divided into four parts namely (i) Air inlet chamber (20 cm from the ground level), (ii) heating chamber (60 cm height from the ground level), (iii) plenum chamber (30 cm above the heating chamber) and (iv) drying chamber (30 cm above the plenum chamber) and it requires a housing shed of 3 x 3 m size. The dryer as well as the burning chamber have rectangular cross section.

The dryer was fabricated with 20 cm ground clearance. This was fabricated using 20 x 5 mm M.S flat and 16 gauge G.I. sheets on all the sides for the fresh air to enter with the help of movable doors hinged on the main frame using 75 mm M.S. hinges. Hinges were provided for regulating the supply of fresh air. Above the air inlet opening, the heating chamber was provided to burn the coconut shells. The heating chamber was divided into two separate compartments. The heating cum heat exchanging chamber was placed at a vertical inclination of 4 degree for smooth flow of flue gases to the chimney. Two separate chimneys have been provided for proper escape of flue gas and smoke. The height of the chimney was 1.5 m for better draft. Butterfly valves were provided in the exhaust pipes. A separate smoke chamber was fabricated so that smoke does not accumulate in the burning chamber and for better natural draft. The empty space provided above the burning chamber is known as plenum chamber. The top portion of the dryer is known as drying chamber. The weld mesh for stacking copra is made of 10 gauge, 25 ×25 mm weld mesh. Wire mesh was also provided to avoid the falling of small copra pieces and coconut pith on the heating chamber and for even distribution of hot air in the drying bin. On one side of the drying chamber a door has been provided for easy loading and unloading the coconuts. The sides of the heating chamber are covered by the 6 mm thick bamboo plywood sheets.

The dryer developed requires eighty half shells in each tray to make one row. The coconut shells were interlocked and laid on the tray. The hollow end of the row of shells was ignited (a little kerosene being added to help initial burning). When the shells begin to burn well and without smoke, the tray was pushed inside the heating chamber. The shells burn uniformly by the incoming air for which ventilation holes is provided on the door. The number of holes required was standardized based on tests conducted. Additional ventilation door was provided with provision to open and close in case of necessity and to retain the heat once the shells were burnt completely. Each fuel tray

Shell fired copra dryer being demonstrated at Bedadaka, Kasaragod District, India

Sl. No.	Characters/Items	Conventional method	Copra Dryer
1	Better copra quality	5	10
2	Higher value of copra in local market	5	10
3	More efficient drying method	5	10
4	Less time taken for drying coconut	4	10
5	Less skill required for use of method	10	6
6	More easy to use method	5	10
7	Low risk and injury hazard	10	5
8	Higher need for repair and maintenance	0	10
9	Less drudgery involved	4	10
10	More scope of use in local households	10	7

Table 1. Matrix Scoring on assessing the efficiency of copra dryer

produced heat for 6 h with a temperature of about 80 - 82 °C. Generally after about 6 h, when the temperature drops below 60 °C, the fuel trays were removed from the dryer, cleaned and reloaded with fuel, refired and replaced in to the respective burning chambers. About 4 loads of fuel were required to dry the copra to about 6.25 % d.b. moisture content. The heat generated by burning of the fuel heated the heating chamber. The air above heating chambers got heated up and moved upwards through the layers of fresh coconut kernel and the hot air laden with moisture escaped from the top of the drying chamber in to the atmosphere, and fresh air entered through the ventilation holes provided at the bottom. This phenomenon was carried out with the help of natural convection.

The cost of the dryer was estimated to be Rs. 28,000.00. The cost involved to dry one kilogram of copra in the copra dryer was worked out and found to be Rs. 2.43. As the quality of copra dried in the copra dryer is good it will fetch higher price in the domestic as well as international market. This dryer will be very useful for farmers engaged in copra processing. The main advantage of this dryer over other natural convection dryers is that fuel need to be loaded only once in six hours where as in other dryers fuel needs to be loaded every 15 minutes. Thus once the fuel is charged the farmers can do other works and need not stay near the dryer.

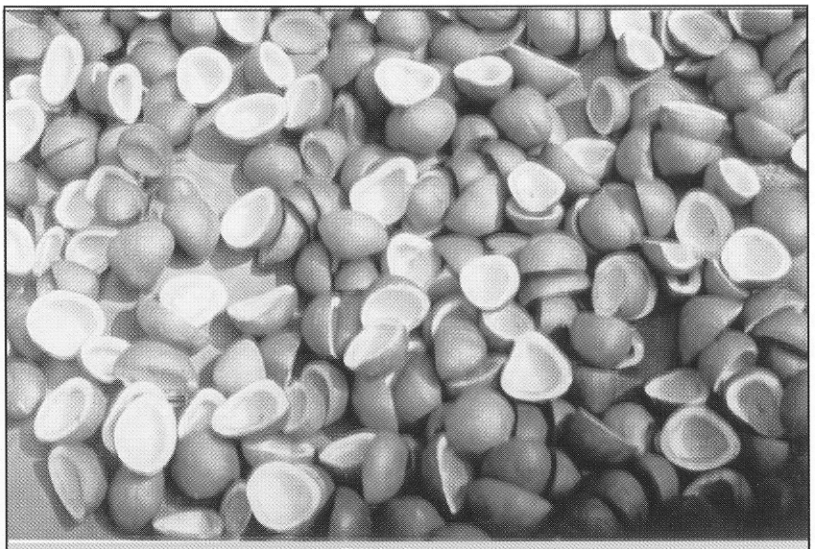
Training of farmers and rural women on the use of shell fired copra dryer

Training programmes were organized by CPCRI for farmers and members of women's self help groups to enhance their knowledge and skill on the use of shell fired copra dryer for the production of quality copra production. Under the NATP sub project on Women Empowerment, training programmes were organized for members of Kudumbasree units at Bedadka and Iriyanni in Kasaragod District. Similarly, training programmes were also organized under the Institute Village Linkage Programme for the selected farmers and members of self help group at Banam and Madikkai in Kasaragod District. Participatory assessment of performance of

Sl.No.	Material	Size	Quantity	Rate (Approx.	Amount in Rupees
1	M.S. Angle	40 x 40 x 3 mm	31 m	56kg, (@ 22/kg	1,232.00
2	M.S. Angle	25 x 25 x 3 mm	12.2 m	14kg, @ 22/kg)	308.00
3	M.S. Angle	25 x25 x5 mm	4.1 m	8kg. @ 22/kg	176.00
4	M.S.Flat	20 x 5 mm	36.0 m	29kg. @ 22/kg	638.00
5	M.S.Flat	25 x 5 mm	15.0 m	15kg, @ 22/kg	330.00
6	G.I.Sheet	16 G. 240 x 120 cm	5 Sheet	@ 1,100/ sheet	5,500.00
7	A.C.Sheet	6 mm x 240 x 120 cm'	1 Sheet	@ 450/ sheet	450.00
8	A.C.Sheet	6 mm x 180 x 120 cm	2 Sheet	@ 350/ sheet	350.00
9	A.C.Sheet	6mm x 120 x1 20 cm	1 Sheet	@ 225/ sheet	225.00
10	Bamboo plywood	6 mm x 240 x 120 cm	1 Sheet	@ 1000/ sheet	1,000.00
11	Weld Mesh	10 G x 25 x 25 mm	3.2 sq.m	@ 100/ sq.m	320.00
12	Wire Mesh	240 x120 cm	2.88 sq.m	@ 166.5/sq.m	480.00
13	G.I sheet.	20 G x 120 x 90 cm	1 Sheet	@ 300	300.00
14	G.I. Elbow	75 mm	2 Nos	@ 125 each	250.00
15	M.S. Hinges	75 mm	14 Nos.	@ 10 each	140.00
16	Screw bolt nuts	20 x 6 mm	100 Nos.	@ 100	100.00
17	M.S. Bolt nuts		1kg.	@ 60/ kg	120.00
	Fabrication Charges	Say			2,700.00
			Total		14,969.00
	Total Amount (INR)				15,000.00

Material and Cost Estimation for the Fabrication of Copra Dryer

copra dryer compared to the traditional sun drying method was documented as farmers' reaction through matrix scoring on a 10 point scale (Table 1). The general feedback from the farmers was that they were able to produce hygienic copra even during the monsoons using the copra dryer which fetches a higher market rate.



Edible Copra

Economic Analysis of Copra Dryer

The cost of the dryer was estimated as Rs 15,000/- and the expected life is 10 years. The use of the dryer for copra production was assumed to be a minimum of 200 batches. Straight line method of depreciation was adopted for calculating annual depreciation. Interest is assumed to be 10 % per annum and annual the maintenance cost at 5 % of initial cost. Assumption has been made for cost of nut and approximate output of copra.

Fixed Cost	(Rs)
Annual depreciation	1500
Interest @ 10% per annum	1500
Maintenance Cost @5% of initial cost	750
Total fixed cost	3750
Fixed cost/ batch (Assuming that the copra dryer will be operated for 200 batches in a year)	18.75
Variable cost per batch	
Average cost of nuts	
@Rs.5.00/ nut for 1000 nuts	5000
De-husking charge for 1000 nuts	240
Labor charges for 3 shifts @Rs. 175/ day	375
Transportation charges	250
Electricity, water, etc. (lump sum)	50
Total variable cost	5915
Total cost (fix cost + variable cost per batch)	5933.75 or say 5934
Returns	
Revenue from sale of 175 kg of copra @ Rs.35	6125.00
Value of husk and 50% shell (50% shell being consumed as fuel)	200.00
Total returns/ batch	6325.00
Net returns/ batch	391.00
Net additional revenue that can be realized for drying 200 batches in one year	78200.00
Cost drying one kg of copra excluding the cost of nuts	533
Cost of drying one nut	0.93
Thus by operating the copra dryer for 39 batches, the farmer will get back the invested amount for purchasing the dryer	

Conclusion

Compared to the dryers developed earlier, the new shell fired copra dryer is more efficient for production of quality copra. Farmers, entrepreneurs and members of self help groups in rural areas involved in copra production and marketing can effectively use this dryer to produce hygienic copra even during the monsoons, ensuring a higher market rate.

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