Development of an improved tray type mechanical copra dryer (1)

R. T. PATIL (2) and JASWANT SINGH (3)

Summary. — For drying the copra in rainy season without affecting the quality a tray type (mixed flow) mechanical dryer was developed at Central Plantation Crops Research Institute, Kasaragod, India. Electricity being the cheapest and no necessity of indirect heating ; was used as energy source. The dryer was fabricated from the materials such as wood, GI sheet, AC sheet, Asbestos rope and MS sheet. Components of the dryer were drying chamber, air distribution unit, plenum chamber, heating unit and blower. Drying chamber accomodated air distribution unit in the centre with copra trays on its both sides. The air was blown by 1.5 hp motor operated blower on 8 kW heaters. This hot air then was circulated through the material on the trays. The capacity of dryer was 1,000 nuts per batch and drying time required was about 30 hours. The cost of the dryer was worked out to be Rs. 8,000 — and the cost of drying came to about Rs. 0.58 per kg of dried copra.

INTRODUCTION

India is the third largest coconut growing country with an annual production of 5,800 million nuts from a 1.1 million hectare area. Fourty per cent of this quantity is converted into copra for oil extraction which is used for edible as well as for industrial purposes. The drying from October to May can be performed in the open sun by spreading the cups for 7 to 10 days. This kind of copra making is not possible in the rainy season. Coconut kernel being a very good substrate for micro-organisms, gets infested if not subjected to drying within 4 hours after splitting [Thampan, 1981]. To get mould free copra during the rainy season the following recommendations [Grimwood, 1975] are essential to be followed :

1) the moisture content must be reduced from 45-50 p. 100 to 40-35 p. 100 preferably within 24 hours ;
2) during the subsequent 24 hours the moisture content should be reduced to about 20 p. 100 ;
3) in the next twenty four hours the moisture content should be reduced to 5-6 p. 100.

To achieve this, in the rainy season artificial drying becomes indispensible. There are two types of dryers so far reported to be developed for copra drying in different coconut growing countries : 1) direct type, 2) indirect type.

1. - Direct type. — These are known as « Kiln dryers », where cups are exposed to the flue gas from the burning pit e.g. Pasearjan type, Sariaya type, Malaysian cooke type Kilns, Ceylon type [Grimwood, 1975]. The copra obtained from such types of dryers was reported to be black and ununiformly dried. There was no control over the drying air temperature, so in some cases case-hardening of the endosperm also takes place. This type of copra shows very poor keeping quality in storage.

2. - Indirect type. — In such type of dryers, the flue gases are passed away by the chimney and fresh air is heated to the required temperature by heat exchanging/distributing unit e.g. Samoan dryer, Comoro dryer, The New College copra dryer, Indonesian hot table dryer, Inclined chamber dryer and Chula copra dryer. These dryers use wood, mineral oil, or agricultural waste as fuel. The hot air is circulated either by natural convection or by power operated blower. In case of natural convection dryer it was reported that improper air circulation causes the deterioration of quality. Hence, such types of dryers were used in combination with open sundrying. In some dryers irregular drying and fire hazards have also been reported [Grimwood, 1975]. Where the air circulation was by forced convection the initial cost of the dryer was very high. Another disadvantage to make use of these dryers under Indian conditions is the large area and building required to house them.

Keeping all these points in view, a mechanical dryer using electrical energy for drying of copra was fabricated [Jaswant Singh *et al.*, 1981] at Central Plantation Crops Research Institute, Kasaragod, India.

I. — DESCRIPTION OF THE DRYER

This was a tray type forced circulation dryer as shown in figures 1 and 2. The main components of the dryer are given below and the materials required for fabrication are given in table I :

1) drying chamber ;
2) plenum chamber and air distribution unit ;
3) heating unit ;
4) blower unit.

1. — Drying chamber.

It was made of jackwood planks lined with 22 gauge G.I. sheet. The air distribution chamber was provided in the centre and both sides of it welded wire mesh trays of 92 × 45 cm size were kept on aluminium angle runners. The drying chamber accomodates 10 trays on each side. The adjustable exhaust was provided at the top of the chamber.

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TABLE I. — **Materials required for mechanical copra dryer**
(Matériels nécessaires à la construction du séchoir à coprah)

Item	Material	Quantity
Drying chamber *(Chambre de séchage)*	Jackwood *(Bois de jaquier)*	0.160 m^3
	G.I. sheet (22 gauge) *(Tôle galvanisée - « gauge » 22)*	6.32 m^2
	Aluminium angles (25 × 25 × 3 mm) *(Cornière d'alu.)*	40.50 m
	Welded wire mesh (50 × 25 mm) *(Métal déployé soudé)*	8.70 m^2
Plenum chamber *(Conduit d'air)* and *(et)* Air distribution unit *(Unité de distribution d'air)*	G.I. sheet (22 gauge) *(Tôle galvanisée - « gauge » 22)*	3.055 m^2
	Plaster of Paris *(Plâtre de Paris)*	5.0 kg
	Asbestos cloth *(Tissu d'amiante)*	2.0 m^2
	Asbestos rope *(Tresse d'amiante)*	15.0 kg
	Aluminium angle (25 × 25 × 3 mm) *(Cornière d'alu.)*	8.70 m
Heating unit *(Unité de chauffage)*	M.S. sheet (3 mm thick) *(Tôle métallique de 3 mm)*	1.0 m^2
	Ele. room heaters (400 W each) *(Radiateurs électriques ordinaires de 400 W)*	20
Blower *(Ventilateur soufflant)*	30 cm ∅, 6 blade *(ailettes)*	1
Motor *(Moteur)*	50 hz, 3 phase, 1.5 hp, 2,800 rpm *(t/min)*	1
Control panel *(Tableau de contrôle)*	Motor starter *(Coffret de démarrage)*	1
	Heater switches, 15 A *(Interrupteur des radiateurs)*	3
	Main switch, 15 A *(Interrupteur général)*	1
	Energy regulator *(Régulateur de tension)*	1

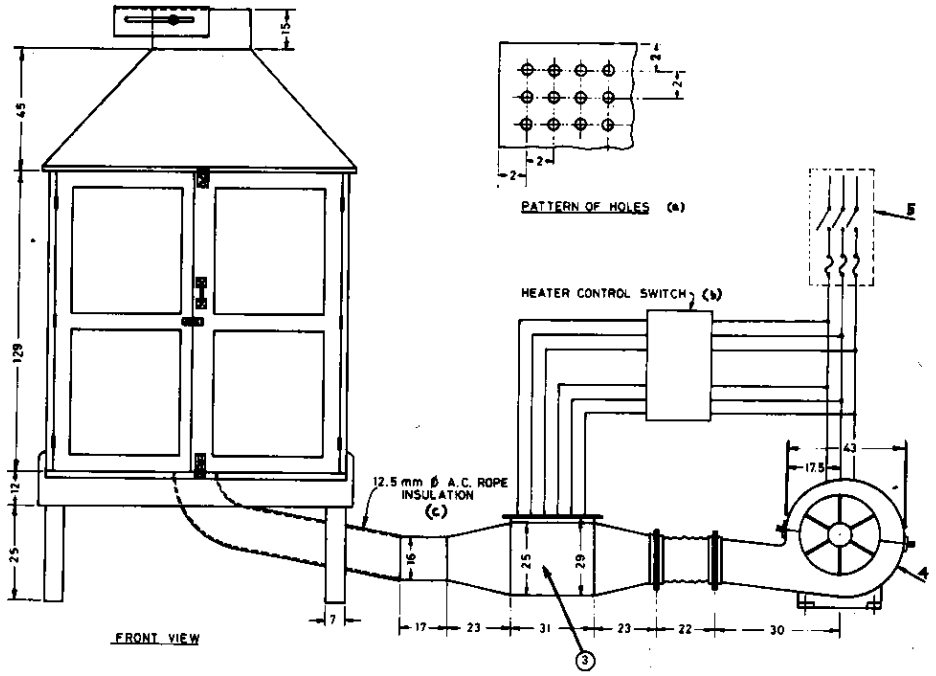
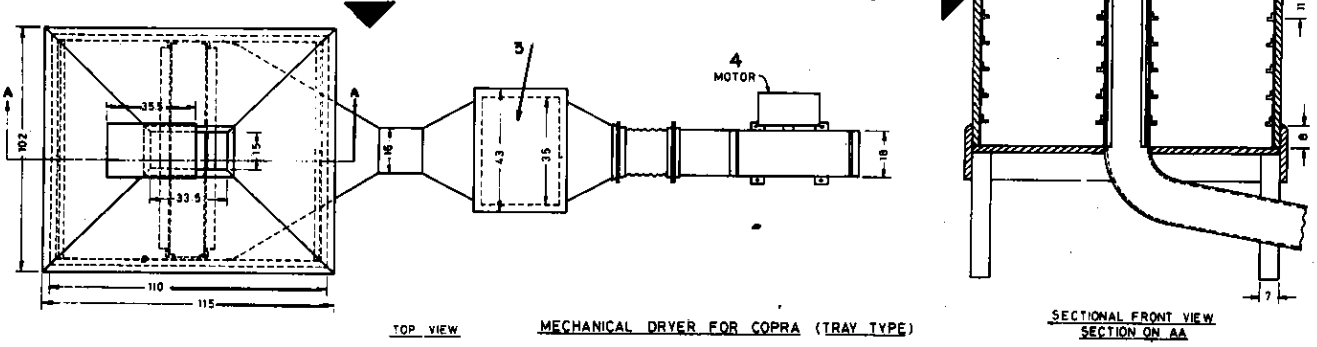


FIG. 1. — Séchoir à coprah, mécanique de type à plateaux.
(a) disposition des trous ;
(b) interrupteur des échangeurs ;
(c) isolement par corde d'amiante.

FIG. 2 A. — Séchoir à coprah, vue d'en haut.

FIG. 2 B. — Séchoir à coprah, vue de face, coupe A-A.



2. — Plenum chamber.

It was made of G.I. sheet and covered with asbestos cloth and partially by asbestos rope for insulation with plastering by plaster of Paris. It was connected to the air distribution chamber at one end and the heating unit at the other.

3. — Heating unit.

There were 20 air heaters (ordinary room heaters) of 400 W each arranged in the M.S. sheet box of 3 mm thickness. The end connecting to the plenum chamber was provided with a butterfly value to regulate the air flow.

4. — Blower unit.

A 1.5 hp, 2,880 rpm motor was used as prime mover for 60 m³/min capacity blower. The air passed over the bank of heaters and got heated up and distributed by air distribution unit. The motor operation was controlled by a direct on line starter and the heaters were connected through three switches. The temperature was controlled with an energy regulator and adjustment of the inlet and exhaust to the drying chamber.

II. — TESTING OF THE DRYER

This dryer was tested for its design capacity of 500 nuts. The inlet air temperature was kept at 60 °C. It was observed that the drying time required was average 27.5 hours for bringing down the moisture from 46 p. 100 to 6 p. 100 (WB). The cups were kept facing up during drying. The capacity per tray was 25 nuts. The energy utilization efficiency was calculated by the following formula.

$$\eta_t = \frac{LA\lambda(Mo - Mf)}{FTC(100 - Mf)}$$

Where,

L = loading density in kg/m² ;
A = total area of the trays, m² ;
λ = latent heat of vaporization, kcal/kg ;
Mo = initial moisture content p. 100, wet basis ;
Mf = final moisture content p. 100, wet basis ;
T = actual drying time in hours ;
F = capacity of installation (kW) ;
C = conversion factor from kWh to kcal = 1,1626 × 10³.

The energy utilization efficiency at 500 nuts per batch capacity was found to be 22.70 p. 100. The copra obtained per batch was 80.5 kg (Table I). As per the published reports on copra drying, the efficiency of drying was reported to be low at capacities lower than 20 kg/m² and at constant air velocity the time required was not much different for the loading densities between 20 to 50 kg/m² [Rajasekharan *et al.*, 1961]. In this case capacity was 23.8 kg/m² for the first 12 hours and after that it was only 9.8 kg/m² when shells were removed. The average capacity over the period of drying was only about 15 kg/m².

This capacity was insufficient to cover the whole tray and thereby created a channeling effect. The time required for drying at this capacity was observed to be relatively more. The insufficient covering of trays also nullified the intended better heat and mass transfer effect due to mixed flow of drying air.

III. — MODIFICATIONS IN THE DRYER

In view of the facts observed during the testing the dryer for the designed capacity, it was decided to increase the loading density to avoid the channeling effect after the removal of the shells from the kernel and also to make use of the dryer at the optimum level. To accommodate this additional capacity, cups were arranged facing sides till the shells were removed. To keep the uniformity of the air required for this purpose of additional capacity, the area of the perforations was increased to four fold i.e. the area of perforations was about 5 p. 100 of the distribution chamber area. The holes were patterned as shown in the figure 1. The plenum chamber was covered with asbestos rope insulation up to half the length. The dryer was then tested for the higher capacity of 1,000 nuts per batch.

IV. — TESTING OF THE DRYER AFTER MODIFICATIONS

The maximum temperature of 60 °C was attained after 15 min running of the dryer. The temperature was further maintained with energy regulator position at high, air inlet at half and air exhaust at one fourth of the opening. The results of this and earlier tests are presented in table II. The air velocity was uniform for all the trays at 25 m/min parallel to the material. The air velocity through the material was 10 m/min. The rate of flow of air through the material was 6 m³/min. At the arrangement of the cups

TABLE II. — **Dryer test results** *(Résultats des essais du séchoir)*

Test	Capacity			Copra content/ batch *(Teneur en coprah/lot)* (kg)	Energy required *(Energie requise)* (kcal/kg)	Energy utilization efficiency *(Rendement énergétique)* (p. 100)	Drying time required *(Temps de séchage)* (h)
	nuts/tray (1) *(noix/plateau)*	kg/tray with shells *(kg/plateau avec coque)*	kg/tray only kernel *(kg/plateau, amande seule)*				
1	25	11.25	4.85	80.00	48,000	22.14	28
	(25)	(11.90)	(4.90)	(80.50)	(48,300)	(22.70)	(27.5)
2	25	12.60	4.95	81.00	48,600	23.25	27
3	50	25.70	9.70	164.00	98,400	43.80	29.50
	(50)	(25.22)	(9.68)	(165.00)	(97,000)	(42.65)	(30.25)
4	50	24.75	9.65	166.00	99,600	41.50	31

( ) Figures in the brackets indicate average values *(les chiffres entre parenthèses indiquent des valeurs moyennes)*.
(1) The size of drying tray was 92 × 45 cm *(les dimensions du plateau de séchage sont de 95 × 45 cm)*.

facing sides the capacity was 50 nuts/tray. The loading densities before and after the shell removal were 50.4 and 19.36 kg/m². The average loading density over the period of drying was found to be about 35 kg/m².

The arrangement of the cups after shell removal was kept at cups facing up. The capacity per batch was 1,000 nuts and copra obtained was about 165 kg. Due to these modifications and arrangement of the cups, the capacity was increased by 100 p. 100, whereas the energy utilization efficiency was increased from 22.7 p. 100 to 42.65 p. 100.

V. — COST ANALYSIS OF COPRA DRYING BY MECHANICAL COPRA DRYER

The initial cost of the dryer was worked out to be Rs. 8,000. The expected life of the dryer and the number of days' use per year needed to make the dryer economical were considered as 10 years and 200 days respectively. The unskilled labour who did dehusking, deshelling per batch could also operate the dryer. For interest calculations the subsidised rate of 10 p. 100 and half the new cost as capital per year were considered. The straight line method was adopted for calculating depreciated value per year,

$$\text{Annual depreciation} = \frac{\text{Initial cost}}{\text{Life of the dryer in years}}$$

The rate of electrical energy consumed was taken as Rs. 0.17 per kWh (as for industrial purposes in Kerala). Based on these estimates the cost of copra drying was calculated as given in table III. The cost of drying per kg of copra was found to be Rs. 0.58.

VI. — SPECIAL FEATURES OF THE DRYER

1) Design was very simple and could be fabricated in any moderately equipped workshop ;

2) The location of the heating unit outside the drying chamber made possible the use of locally available material like wood for drying chamber which thereby reduced the cost of fabrication ;

3) It could be operated by an unskilled labourer ;

4) Quality of the copra obtained was good white and free from mold infestation ;

5) No fire hazards as drying material and wooden chamber were away from heating elements ;

6) The only care required was switching off the heaters 15 min before the blower at the end of the operation. In any case the heaters should not be on without the simultaneous operation of the blower ;

7) Required only about 6 m² area for housing.

CONCLUSION

This dryer could be a feasible proposition for the cooperatives in the Indian villages. Taking the average yield of a palm at 50 nuts/year, and operation of the dryer from June to December for about 200 days, so that about 28 batches could be handled with 6 days per week operation, and at the recommended planting density of 200 palms/hectare, this dryer can cater to the needs of 35 hectare of land i.e. to about 70 farmers owning average holdings of about 0.5 hectare.

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TABLE III. — **Cost analysis of copra drying** *(Analyse des coûts de séchage du coprah)*

1. Cost of the dryer *(Coût du séchoir)* : Rs. 8,000 (1) ;
2. Expected life of the dryer *(Durée de vie du séchoir)* : 10 years *(ans)* ;
3. Use of the dryer in days in a year *(Temps d'utilisation par an)* : 200 days *(jours)* ;
4. Labour requirement for operation of dryer including dehusking, splitting, of nuts and removal of shells per batch *(Main-d'œuvre nécessaire au fonctionnement du séchoir, y compris débourrage, ouverture et décoquage des noix de chaque lot)* : 3.5 mandays *(jours/homme)* ;
5. Time required per batch for drying *(Temps nécessaire au séchage d'un lot de noix)* : 2.5 days.

1. — Fixed cost *(Coût fixe).*

— Annual depreciation *(Amortissement annuel)* :	Rs. 800.00.
— Annual interest at 10 p. 100 on half the new cost *(Intérêt annuel à 10 p. 100 sur la moitié du coût de l'appareil neuf)* :	Rs. 400.00.
— Annual maintenance at 10 p. 100 of annual depreciation *(Entretien annuel à 10 p. 100 de l'amortissement annuel)* :	Rs. 80.00.
— **Total fixed cost *(Coût fixe total)* :**	**Rs. 1,280.00.**
— **Fixed cost per batch *(Coût fixe par lot)* :**	**Rs. 16.00.**

2. — Operating cost per batch *(Coût de fonctionnement par lot).*

— Labour charges at Rs. 10.00 per day *(Main-d'œuvre à 10 Rs/jour)* :	Rs. 35.00.
— Cost of electricity at Rs. 0.17/kWh *(Coût de l'électricité à Rs 0,17 kWh)* :	Rs. 45.90.
— For total of 270 units *(Pour un total de 270 unités)* :	
— **Total operating cost per batch *(Coût total du fonctionnement par lot)* :**	**Rs. 80.90.**
— Cost of drying per batch *(Coût du séchage par lot)* :	Rs. 96.90.
— Quantity of copra obtained per batch *(Quantité de coprah d'un lot)* : 165.00 kg.	
— Cost of drying per kg of dried copra *(Coût du séchage par kg de coprah séché)* :	Rs. 0.58.

(1) 1 Rupee *(Roupie)* = 0.16 US$ (approx.).

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RÉSUMÉ

Mise au point d'un séchoir à coprah mécanique amélioré du type à plateaux.

R. T. PATIL et JASWANT SINGH, *Oléagineux,* 1984, **39,** N° 1, p. 31-37.

Pour sécher le coprah pendant la saison des pluies, sans en affecter la qualité, un séchoir mécanique du type à plateaux (à air brassé) a été mis au point au Central Plantation Crops Research Institute, Kasaragod, Inde. L'électricité a été choisie comme source d'énergie la moins chère, ne nécessitant pas l'utilisation de chauffage indirect. Le séchoir est construit à partir de matériaux tels que le bois, la tôle galvanisée, le tissu d'amiante, la corde d'amiante, et la tôle métallique. Le séchoir est composé de : chambre de séchage, unité de distribution d'air, conduit d'air, unité de chauffage et ventilateur soufflant. L'unité de distribution d'air est placée au centre de la chambre de séchage, avec les plateaux de coprah des deux côtés. La distribution d'air s'effectue grâce à un ventilateur à moteur de 1,5 cv, soufflant sur des radiateurs de 8kW. L'air chaud circule ensuite dans les noix sur les plateaux. La capacité du séchoir est de 1 000 noix par lot, et le temps de séchage est de 30 heures environ. Le coût de l'appareil a été calculé à 8 000 Rs. — et le coût du séchage est de 0,58 Rs. environ par kg de coprah séché.

RESUMEN

Desarrollo de un secador de copra mecánico y perfeccionado, de tipo secador de bandejas.

R. T. PATIL y JASWANT SINGH, *Oléagineux,* 1984, **39,** N° 1, p. 31-37.

Para secar la copra durante la estación de lluvias, sin perjudicar la calidad, el Central Plantation Crops Research Institute, en Kasaragod, India, ha desarrollado un secador mecánico de tipo secador de bandejas (por agitación de las capas de aire). Se escogió la electricidad como fuente de energía más barata, y que no necesitaba ninguna calefacción indirecta. El secador se fabrica con materiales como madera, chapa galvanizada, tejido de amianto, cuerda de amianto y chapa metálica. El secador se compone de una cámara de secado, de una unidad de distribución del aire, de un canal de aire, de una unidad de calefacción y de un ventilador impelente. La unidad de distribución de aire se coloca en el centro de la cámara de secado, con las bandejas de copra a ambos lados. La distribución de aire se lleva a cabo mediante un ventilador de motor de 1,5 C.V., que sopla en radiadores de 8 kW. Luego el aire caliente circula entre los cocos en las bandejas. La capacidad del secador es de 1 000 cocos por lote, y el tiempo de secado es de unas 30 h. Se calculó el costo del aparato en 8 000 Rs, y el costo del secado en unas, 0,58 Rs por cada kg de copra seca.

Mise au point d'un séchoir à coprah mécanique amélioré du type à plateaux (1)

R. T. PATIL (2) et JASWANT SINGH (3)

INTRODUCTION

L'Inde vient à la troisième place dans le monde pour la production de noix de coco, qui atteint annuellement 5 800 millions de noix pour une surface de 1,1 million d'hectares ; 40 p. 100 de cette quantité sont convertis en coprah pour l'extraction d'une huile destinée aussi bien à l'alimentation qu'à l'utilisation industrielle. D'octobre à mai, le séchage peut se faire au soleil, en étalant les demi-noix dehors pendant 7 à 10 jours. Cependant, il n'est pas possible d'utiliser cette technique pendant la saison des pluies. L'albumen de noix de coco, étant un excellent substrat pour les microorganismes, s'infecte s'il n'est pas soumis au séchage dans les 4 heures suivant l'ouverture [Thampan, 1981]. Pour obtenir du coprah sans moisissures pendant la saison des pluies, il est essentiel d'observer les recommandations suivantes [Grimwood, 1975] :

1) le taux d'humidité doit être réduit de 45-50 p. 100 à 35-40 p. 100 sous 24 heures de préférence ;

2) pendant les 24 heures qui suivent, le taux d'humidité doit être réduit à 20 p. 100 environ ;

3) au cours des 24 heures suivantes, le taux d'humidité doit être réduit à 5-6 p. 100.

Pour ce faire, il est essentiel de recourir au séchage artificiel pendant la saison des pluies. Actuellement, deux types de séchoir ont été mis au point dans les différents pays producteurs de noix de coco : 1) type direct, 2) type indirect.

1. - Type direct. — Dans un séchoir de ce type, appelé « four », les demi-noix sont exposées au gaz de combustion du foyer (par exemple, fours type « Pasearjan », « Sariaya », type Cooke de Malaisie, type Ceylan [Grimwood, 1975]). Le coprah

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