

FINAL REPORT

1. Institute Code No. **Tech.I(231)2**
2. I. C. A. R. Code No. **Continuation of the Project No.PI-77/9-ICI MBQ/0311**
3. Name and Address of Research Institute/Centre: **Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala**
4. Project Title: **Design, development and testing of a copra dryer of 1000 coconuts/batch using agricultural waste as fuel**

5. Name and Designation of Project Leader:

**1. SJK ANNAMALAI
Scientist SI (FM&P)**

**2. SJD BOSCO
Scientist SI (ASPE)**

6. Name(s) and Designation(s) of Project Associates including Project Leader and work to be done:

Sl. No.	Name and Designation	Time spent (mean months)	Work done
1.	SJK ANNAMALAI Scientist SI (FM&P)	8	Design and development of dryers for the plantation crops like coconut, arecanut pepper, cardamom etc.
2.	SJD BOSCO Scientist SI (ASPE)	2	Testing and evaluation of 3000 coconuts dryer and to find out the proper fuel feeding rate to achieve good quality copra.

7. Location of Research Project with complete address (Division/Section/Sub-Centre)

**Technology section
Central Plantation Crops Research Institute
Kasaragod 670 124.**

8. Date of start

Feb. 1985

9. Date of termination

December 1987

10. (a) Objectives (Not more than 150 words)

- (i) To develop a low cost dryers of different capacity for drying coconut.**
- (ii) To test these dryer for the suitability to dry other plantation crops like pepper, cardamom, ginger etc.**
- (iii) To modify these dryers, if necessary, to dry the above said plantation crops.**
- (iv) To work out the cost benefit analysis for these dryers.**
- (v) To evaluate the developed dryers in the farmers' field for suitability.**

(b) Practical Utility including background information (Not more than 150 words)

Drying is one of the important operation to get good quality of final farm produce. Most of the farm produce from the plantation is containing high moisture content. After the harvest, the produce should be dried to bring down the moisture content at lower level for safe storage and/or further processing. Otherwise, the produce will be spoiled by micro-organisms which will reduce the quality of the produce in turn reduce the farmer's income. Sun drying is the common practice of drying the farm produce in which the produce will be spread under the open sun on cement or mud floor. The quality of the produce obtained may not be good because prolonged exposure under open conditions results in microbial infestation and contamination from dirt. The microbial infestation can be effectively reduced if drying is done more quickly by artificial means and in proper time. The dryers which are operated by using electrical energy will not be economical and getting continuous electrical supply in the villages is not possible. Therefore, it was decided to develop low cost dryers using agricultural waste as fuel for drying the produce like coconut, pepper, cardamom, ginger etc.

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

KASARAGOD-670 124, KERALA

R P F III

Project No. **Tech. I (231) 2.**

Date of Start: **Feb. 1985**

11. Technical Programme :

12. ~~Final Report.~~ 19 ~~19~~

Programme for 1985:

1. Design, fabrication and perfecting the copra dryer of 1000 coconuts capacity. (SJK Annamalai)

Programme for 1986:

1. Fabrication of one more prototype dryer of 100 coconuts capacity.

2. Testing of other plantation crops produceer namely pepper and ginger in small holder's dryer.

3. Design of a dryer of 3000 coconuts capacity (in collaboration with Central State Farm, Aralam).

4. Design and fabrication of a deryer of 100 coconuts capacity.

5. Modifying the 1000 coconuts dryer and standardising the drying system for cardamom drying.

6. Economic analysis of copra drying in field condition in collaboration with Agril. Economics Division.

(SJK Annamalai)

Programme decided in mid-term reviews - 1986:

1. Testing the small holders dryer for drying the large cardamom

(SJK Annamalai)

Programme for 1987:

1. Testing and evaluation of 3000 coconuts capacity dryer (in collaboration with Central State Farm, Aralam).

(SJK Annamalai)

(SJD BOSCO)

R P F III

Project No.

Tech. I (231) 2

Date of Start:

Feb. 1985.

Final Report: 1985- 1987

Final Report:

19

-19

1. Development of 100 and 1000 coconut capacity dryer

(SJK Annamalai)

These dryer are of 'batch type' working on indirect heating and natural air connection principles, using dry agricultural waste as fuel. The capacity of the dryers are (i) 1000 to 1200 coconuts and (ii) 100 coconuts.

The dryers are mainly comprised of (a) Drying chamber (b) plannun chamber (c) burning cum heat exchanging unit and (d) chimney with regulators. The dryers can be fabricated from easily available materials such as asbesters cement sheet, G.I. sheet, MS angler, MS flats, wire mesh etc. The details of the dryers are shown in Fig. 1&2.

A. Drying chamber: The drying chamber is the upper portion of the dryer which is supported on MS angle frame. It is made of asbestos cement sheets on sides and wire mesh at the base (drying plat form). In the medium holders dryer, three doors on hinges are provided on one side of the chamber to facilitate easier loading and unloading of the produce. The produce to be dried is kept in this chamber. [cont. from the next paper]

2. Testing the 1000 coconut capacity dryer for the suitability to dry other produce: (SJK Annamalai)

(i) **Arecanuts** 350 Kg of fresh arecanut canbe dried in 87 hours (11 days) by using 240 kg of coconut husk as fuel. The cost of drying is Rs.1.70 per kg of dry arecanut. The arecanut dried in the dryer was found to be uniformly dried and of good quality as the cracks to the nuts developed during drying is less than 5%.

(ii) Green Cardamom

75 kg of fresh green cardamom was dried in this dryer after the modification. The modified dryer consists of 18 trays in 4 layers with a top cover. The green capsules dried in this dryer was found to have slight discoloration and hence the dryer needs minor modification to over come this problem.

3. Design, development and testing of a low cost cardamom dryer for small holders: (SJK Annamalai)

The small holders copra dryer was redesigned and modified for cardamom drying. The dryer consists of fuel burning-cum heatexchange cylinder, plannun chamber, drying chamber, exhaust fan and chimney. The drying chamber has strays arranged in 4 layers in which produce will be spread for drying. The fuel is burnt inside the heat exchanger and the smoke is taken out through the chimney. The hot air from

the plenum chamber is distributed into the drying chamber from all sides through perforated sheets. A cover made of A.C. sheets with an exhaust pipe is provided above the drying chamber. A hand operated exhaust fan working on chain and gear transmission is provided on the exhaust pipe for removing moist air from drying chamber. An electrical fan (11 cm blade sweep) was also tried as an alternative for the hand operated fan.

The drying time taken for drying 20-24 kg of fresh green cardamom in this dryer was 23-24 hours with hand operated fan 26-28 hrs with electrical fan and 40 hrs without fan. The fuel consumption was about 1 kg/hr. The quality of the product dried in this dryer was very good with retention of green colour. The cost of the dryer is Rs.4000/- and it will be very useful for small planters.

B. Plenum chamber: This is the chamber just below the drying chamber and the air gets heated up in this chamber for drying. It is made of asbestos cement sheets supported on MS angles and plates frame. The cross section of the chamber is of trapezoidal shape. The volume and vertical area of cross section of this chamber is of trapezoidal shape. The volume and vertical area of cross section of this chamber are 2.25 m³ respectively in the case of medium holders dryer and 0.16 m³ and 0.17 m² in the case of marginal holders dryer. An adjustable opening is provided at the bottom for fresh air entry into the chamber.

C. Burning cum heat exchanging unit: This unit is housed at the centre of the plenum chamber longitudinally. It is a cylinder made of 22 g GI sheet having a diameter of 45 cm in the case of medium holders dryer and 20 cm in the case of marginal holders dryer. The unit is provided with GI sheet fins on the upper half in the medium holders dryer to provide greater heat transfer. The cylinder is placed at a vertical inclination of 3-4° for smooth flow of flue gases. One end of the cylinder is covered by a murr damper with holder for air entry for combustion and the other end is connected to the chimney. The agricultural waste fuel is burnt in a weldmesh tray inside the cylinder.

D. Chimney: The chimney is made of GI sheet and is provided to a height of 3 metres. It is provided with two butterfly valves to regulate the escape of flue gases, thereby controlling the rate of combustion and temperature of drying air. The chimney is partially covered by asbestos rope cemented with plaster of parts to avoid any danger during handling.

OPERATION OF THE DRYERS:

The produce to be dried is kept in the drying chamber. Fully matured coconuts are dehusked and split into two halves. After draining off the water, the split cups are loaded in stacks with the first two bottom layers facing up and the rest of the layers facing down, arranged in brick fashion. The fuel comprising of both husk and shell is kept in the tray side the cylinder and fired. The damper is closed or partially closed once the combustion of the fuel has started. Fuel is fed as and when required to keep the fire burning.

As the fuel is burnt, the air surrounding the cylinder gets heated up generating a convection air current. The hot air moves up through the wet produce in the drying chamber and hot air laden with moisture escapes through the top of the chamber. A dial thermometer fixed just below the drying platform will help to monitor the drying air temperature. The temperature of drying air is regulated at 70°C for copra drying.

After 8-10 hr. of drying, the shell from which kernels have loosened can be removed. The drying may be continued after a few hours of tempering as the migration of internal moisture to the surface of the kernel is slower. The copra cups are to be raked every two hours for uniform drying. Generally the drying is carried out over 3 days with overnight breaks till the moisture content of copra reached 6% for safe storage. The actual time taken for copra drying will be 32-36 hrs in these dryers.

Performance of the dryers

Table 1. Performance data of the dryer

Sl.No.	Dryer	Produce	Capacity	Drying air temp. °C	Drying time hr.	Quantity of produce Kg	Type of fuel used.	Qty. of fuel used kg	Cost of drying/ kg

I.	MEDIUM HOLDERS DRYER	1. copra	1000-1200 coconut	60-70	33-37	145-160 kg	Coconut Musk shell	110	Rs.13.0
		2. Arecanut	350kg	60-70	87 (11 days)	170	-do-	240	Rs.1.70 per kg of dry arecanut
II.	MARGINAL HOLDERS DRYER	1. Copra	100 coconuts	60-70	32	15	-do-	16	Rs.1.60
		2. Arecanut	35 kg	60-70	80	16	-do-	32	Rs.2.50 per kg of dry arecanut

ADVANTAGES

1. The dryers are versatile in their use as many other plantation crop produce like pepper, ginger etc. can be dried.
2. These are very useful during the monsoon season when sun drying is not possible.
3. Only low cost agri. waste is used as fuel and higher thermal efficiency is obtained.
4. Controlled combustion ensures economical use of fuel.
5. Quality of produce dried is smoke free and very good
6. They are simple in design and safe to operate
7. Occupy very less space and any temporary shed is sufficient for these dryers.
8. They can be fabricated locally
9. These are low cost dryers and can be afforded by medium and marginal holders.

SPECIFICATIONS AND LIST OF MATERIALS

A. Description

1. Type : Batch type
2. Heating mode: Indirect heating with agricultural waste as fuel
3. Air circulation: Natural air convection
4. Capacity: 1000-1200 coconuts Medium holders dryer
or 375 kg areconut |
100 coconuts or | Marginal holder's dryer
350 kg areconut |
5. Area for housing: 7m² for medium holders dryer
0.5 m² for marginal holders dryer

B. Bill of materials

S.No.	Material	Size	Quantity Medium holders	Marginal holders dryer
1.	MS Angle	32x32x6mm	129 kg	-
2.	MS Angle	25x25x6mm	24 kg	-
3.	MS Angle	20x20x3mm	-	9 kg
4.	MS Flat	32x6mm	35 kg	-
5.	MS Flat	25x6mm	12 kg	-
6.	MS Flat	20x3mm	-	4 kg
7.	MS Rod	6 mm	1 kg	-
8.	Weld mesh	50x25mm	4.5 sq.m.	0.6sq.m
9.	Corrugated GI Sheet	100 2x1m size	2 Nos.	-
10.	Plain GI	sheet 100 -10-	1 No.	-
11.	-10-	100 1x0.6m	-	1 No.
12.	MS Sheet	100	1.2sq.m.	-
13.	AG Sheet	2x1m	7 Nos.	-
14.	AG Sheet	-	-	3.6sq.m.
15.	Ringes (MS)	75mm, 50mm	6 Nos.	-
16.	Ringes (MS)	36mm	-	4 Nos.
17.	GI Bolt, nuts	-	25x6mm 2 kg	25x6 0.5 kg

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7.	MS Rod	6 mm	1 kg	-
8.	Weld mesh	50x25mm	4.5 sq.m.	0.6sq.m.
9.	Corrugated GI Sheet	183 2rin size	2 Nos.	2 Nos.
10.	Plain GI	sheet 183 -do-	1 No.	-
11.	-do-	183 1x0.6m	-	1 No.
12.	MS Sheet	183	1.2sq.m.	-
13.	AC Sheet	2rin	7 Nos.	-
14.	AC Sheet	-	-	3.6sq.m.
15.	Hinges (MS)	75mm, 50mm	6 Nos.	-
16.	Hinges (MS)	36mm	-	4 Nos.
17.	GI Bolt, nuts	25x6mm	2 kg	9nuts x 0.5 kg
18.	Aluminium pipe	75 mm	-	1 ppe.

COST ANALYSIS OF COPRA DRYING

BASIC DETAILS	MEDIUM HOLDERS' DRYER	MARGINAL HOLDERS' DRYER
1. Cost of the unit	Rs.4000.00	900.00
2. Expected life	10 years	10 years
3. Minimum use of dryer in a year	150 days	150 days
4. Time required for drying/batch - days	3	3
5. No. of batches/year	50	50
6. Capacity/batch	1000 coconuts	100 coconuts
7. Quantity of final produce/batch	160 kg	16 kg
8. Labour requirement - man days	4	0.5
9. Fuel used/batch-kg	110 kg	16 kg
<u>FIXED COST</u>		
1. Annual depreciation	Rs.400.00	Rs.90.00
2. Annual Interest 10%	400.00	90.00
3. Maintenance cost/annum	100.00	5.00
4. Total Fixed cost/annum	900.00	185.00
5. Fixed cost/batch	<u>18.00</u>	<u>3.70</u>
<u>VARIABLE COST/BATCH</u>		
1. Cost of coconuts	Rs.1650.00	Rs.165.00
2. Dehusking charges	55.00	3.50
3. Labour charges at Rs.25/-man day	100.00	12.50
4. Fuel at 0.50/kg	55.00	8.00
<u>REVENUES</u>		
1. Copra at Rs.12/kg	1920.00	192.00
2. Husk + shell	150.00	15.00
3. TOTAL REVENUES	2070.00	207.00
NET INCOME/BATCH	212.00	25.90
COST OF DRYING/100 Coconuts	1050	1.60
NET ADDITIONAL INCOME YEAR Over selling coconuts as such	10,600/-	795/-
Minimum holding size	5 ha.	0.5 ha

(Rates are assumed at 1965 rates)

4. Testing the 400 coconuts capacity dryer for its suitability to dry the large cardamom, pepper and ginger

The small holders dryer was tested for its suitability to dry large cardamom (Amomum) in Sikkim in collaboration with the cardamom board. This dryer dries 50 to 100 kg of fresh cardamom in 19 hrs. to 28 hrs from the 85% to 8% moisture content. The fuel consumption was found to be 65% less than the conventional method of direct smoking. The original colour of deep maroon and the aroma were retained by drying in this dryer while in conventional method of drying, the colour as well as the aroma were found greatly lost/reduced. The cost of drying per kg of dry produce is less by 10-40%. By using this dryer, one can additionally earn Rs.440/- to Rs.750/- per ha.

The small holders dryer was tested for drying pepper and ginger. 60 kg of fresh pepper could be dried from 71% to 6.5% moisture content in 30 hours. Peeled fresh ginger was dried in 22 hours in this dryer. Hence the small holders dryer can be used as a multi crop dryer.

5. Design of low cost coconra dryer suitable for large holdings (SJD BOSCO)

A large size coconra dryer of 3000 coconuts capacity suitable for large plantations and cooperative processing units has been designed. The dryer is an indirect heating natural convection type dryer using agri. waste as fuel. The overall dimension of the dryer is 4m x 5.6 m x 1.9m with the drying chamber volume of 3.2 m³. The injected air flow through the dryer is 5.35 m³/min. at a temperature of 60°C. The approximate estimated cost is Rs.10,000/-. The design details of the dryer have been given to Central State Farm, Arakon for the contribution.

Because of non-availability of the man power in Central State Farm, Arakon in 1987, the construction work was started only at the end of the year.

6. Determination of fuel feeding rate: (SJD BOSCO)

To know the suitable simple procedure of operation of 3000 coconuts capacity dryer so as to get good quality coconra in short drying time and also to know the effect of heat treatment on drying rate of coconra, trials were conducted in small holder ~~dryer~~ dryer, medium holders dryer and in hot air free convection oven.

In the oven study, the entire drying time was divided into three phases and each phase different drying temperature were tried. The following temperature combination were found more suitable.

Trial No.	Temperature in °C at different phases with drying time in brackets in hour			Total drying time 'hour'
	I	II	III	
1	70(6)	60(6)	50(8)	20
2	70(6)	55(6)	45(9)	21
3	65(8)	55(8)	50(5)	21
4	65(6)	55(6)	45(10)	22
5	60(8)	55(8)	50(10)	26

If the first day temperature exceeds 70°C, the colour of the copra will change to red. If the first day drying temperature is low, the microbial infestation will be there.

To confirm this result, trials were conducted in 400 capacity dryer. It was decided to maintain the temperature at the bottom of the drying chamber is as follows:

- I day - 60 to 70° C
- II day - 55 to 60° C
- III day - 45 to 50° C
- IV day - 45 to 50° C (if necessary)

~~Since the dryer is natural convection type, the temperature~~

Since the dryer is natural convection type, the temperature distribution is not more uniform both vertically and horizontally. Therefore the drying air temperature in the plenum chamber (just below the drying chamber) is maintained as follows:

Day	Meal feeding rate	Total consumption	
		Number	Weight (kg)
I	2 to 2½ husk for every 15 min.	64-80	16-20
II	1½ to 2 husk for every 15 min.	48-64	12-16
III	1½ to 2 husk for every 20 min.	36-48	9-12
IV	-do-	36-48	9-12
		184-240	46-60

It was also observed that by using weld mesh of 50 x 20 mm in 1000 wats dryer, the central portion of the drying chamber is getting more heat. Therefore it was decided to use the wire mesh on the weld mesh to get more uniform heat distribution.

It was also observed that the drying time on first day should be 8 hours or more, in particular during monsoon season to avoid microbial impertation in the copra.

13. Approximate expenditure incurred in the Project: (Give reasons for variation, if any, from original estimated cost)

Since it is the continuation of the project No. Tech. I (231) there is no separate fund was allotted.

14. Publications and material (one copy each to be supplied with this proforma)

a) Research papers

1. SJK Anjanalai, MVM Swayy, RT Patil 1986. Design and development of a natural convection type low cost dryer for medium holders.

b) Popular articles

(Not) Paper presented in the PLACOSYM VII, held at Coonor, Oct. 1986.

c) Reports

1. Institute annual report for 1985 to 1987.

d) Seminars and workshops (Relevant to the Project) in which the Scientists have participated:

(1) Silver jubilee convention of Indian Society of Agri. Engineers held at Shopal 29-31 Oct. 1985.

(2) VII Symposium on Plantation Crops (PLACOSYM VII) held at Coonor 18-19, Oct. 1986.

e) Material developed (such as new varieties of crops or breeds of farm animals, implements, products, etc.)

(i) A dryer of 1000 and 100 coconuts capacity using agri. waste as fuel was developed which can also be used for drying arecanut and cardamon.

(ii) A low cost cardamon dryer suitable for small holders.

(iii) The small holders dryer was tested to know its suitability to dry large cardamon, pepper, ginger.

(iv) The fuel feeding rate to get good quality copra in the short duration.

15. Details (Nos. etc.) of Field/Laboratory Note books and final material and their location

(H I K)

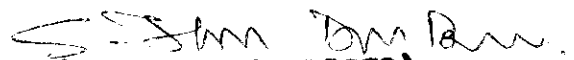
The experimental logbooks are available in the Technology Section of the Institute.

16. Comments/suggestions of Project Leader regarding possible future line of work that may be taken up arising of this project:

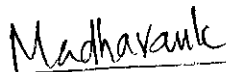
The drying time can be decreased by adopting electrical blomers, thereby the efficiency of the dryer will be increased.

17. Signatures with name of Project Leader and Associates:

(SJK Annamalai)
SI (M&P)


(S. JOHN DON BOSCO)
SI (ASPE)

18. Signature (with comments, if any) of Head of Division/Section/Station:


(K. MADHAVAN)
HEAD OF SECTION

19. Signature (with comments, if any) of Director:

(MK NAIR)
DIRECTOR
