

Design and Fabrication of Semi Automatic Coconut Copra Electric Dryer



R. Thiagarajan, P. Srinivasan, T. Aneesh, S. Mayilvakanan

Abstract: In India Coconut is the major plantation crop in the states of Tamilnadu, Kerala, Karnataka, Kongan region of Maharashtra and Andaman and Nicobar Islands for entire seasons. Copra is the major product from the coconut cultivation earning higher income of small and medium livelihoods. The approval of copra quality is mainly based on how well the copra got dried. Open drying or other conventional methods is the major process of making copra. In adverse weather condition, rainy season the drying process will be very challenging. Many dryers are made and used currently was affordable to medium and large scale copra producers. Those dryers also having limitations in size, high initial cost and nature dependency. There is very few attempt made for Small and individual household copra producers. This paper mainly focuses on how to dry-up the copra in all climate conditions. An electric handy dryer is designed to dry up the coconut copra and other grains. It mainly helps the small scale farmers as a handy dryer unit to dry-up the copra, those who are using coconut as a way of income. Based on the experiments conducted the electric dryer removed high moisture content than forced convection and direct sun dryers.

Keywords: Coconut copra, adverse weather, rainy season, electric dryer.

I. INTRODUCTION

Copra is the essential source for making coconut oil, sweets, biscuits, hair oil, soaps, medicinal and various commercial products. In Conventional method of open drying is not as good at all the times for making copra. The Processing of copra and various agricultural based products has to be given lot of attention in order to make it more productive and efficient on customer markets as well as to meet the quality standards. Drying the copra is a tedious process for small scale business holders in rural places of India. The small scale producers usually rely on either open sun drying or a small cabinet dryer Both these methods of drying have adverse effects on the copra quality.

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Bacteria and fungi attacks are the most common problems of coconut copra in open sun drying since it takes a week to dry up the coconut into useful end product.

Usually when the copra kept outside for open sun drying it may lead to form poor rancid products which is having high acidic content and can't be used further so the productive value of the copra may reduces and the product will become ineffective to extract more oil. More over the open sun drying process of coconut needs lot of space and manpower to prevent them from dust and dirt. During monsoon, conventional method of drying will not help us since it will be raining a lot, hence we need an alternate way to dry up the coconuts and convert it into copras without any spoilage

II. COPRA DRYING PROCESS

Fifty per cent of world production coconut is converted, into copra. In South India in most parts, coconut is the main money making crop. In many districts of Tamilnadu Coconut has more productive value. Edible oil is the prime material from the mature dried Copra after cold pressing, and the by product is coconut oil cake having rich source of vegetable protein used as cattle feed. The Raw coconut is processed to copra by first removal of husk and then splitting in to two shells and then the kernel is dried. In India Open Drying is the common age old method followed by copra producers. During open drying the product is exposed to Sun and the reduction of moisture is made by evaporation. This process is nature depend, open to atmosphere is having high degree of variation having poor control over drying process.

In adverse climates if any variation to the sun light especially poor sunlight, delaying the drying process. The drying delay leads into microbial attack and fungi growth in copra, totally affects copra quality and the yield. The moisture reduction under controlled condition is very essential to the high yield of copra. It is achieved by means of supplying drying energy in a proper way.

C.K.Sankat et al [1] from their study in design, development, construction and evaluation of low initial cost simple solar dryer for the use of Caribbean small – scale copra producers of hundred to hundred and fifty coconuts per week operations. In evaluating the dryer, its performance was compared with that of two natural convection solar crop dryers of conventional design. Indirect dryer having a drying chamber and air pre-heater. The Cabinet direct dryers of B and C type, Air temperatures in the dryers increased above ambient (29°C) by maximum values of 22°C, 11°C, and 9°C for dryers B, C and A respectively. From the study fastest rate moisture content reduction achieved in dryer B and the dryer C being lowest in cost with simple in design.

M. Mohanraj and P. Chandrasekar [2] on their experiment a drier based on forced convection was designed and fabricated with a solar air heater of copper flat plate having an area of 2m^2 . For Indian climates the dryer was tested for copra. The outcome of the copra moisture content from 51.8% to 7.8% of top tray and 9.7% of bottom tray in 82 hours. Based on their report the dryer could produce about 75% high quality copra. As per Patterson & Perez, (1981) the initial moisture content of coconut of 55 %, to be dropped to 6 % for having high yield quality copra. Coconuts to be dried fast to final moisture content to get export good quality, for oil production. Else, the low ambient temperature with high humidity leads to quicker formation microorganisms leads to severe deterioration in quality.

S. Ayyappan and K. Mayilsamy [3] on their research paper of solar tunnel drier of green house with thermal storage for holding and drying around 5000 coconuts at a time. The drier producing air temperature between 55°C to 60°C , for dehydration this range of temperature is relevant to most of the agricultural products. Based on their experimental report 52.3% initial moisture content was brought to 7% on an average time of 60 hrs and with heat storage material further time is reduced to 54 hrs. It will take 153 hrs to reduce the moisture content of coconut copra in open drying for the same level.

K.K.Singh [4] proposed an Electrical heating drier of forced convection with capacity of $965 \times 965 \times 1185$ mm using 16 nos. of 500 W heating elements, with inflow air rate of $0.33 \text{ m}^3/\text{s}$ a constant with inlet air temperatures of 65, 55 and 56°C respectively for 50 kg batches of moisture content high vegetables like of cauliflower, cabbage and sliced onion to prevent it from the microbial attack after harvesting. The efficiencies for energy utilization of the dryer for these vegetables were 30.83, 28.21 and 29..51% From their observation that cabbage taking highest drying time than the Onion and Cauliflower and the overall energy utilization efficiency for Cauliflower is higher than the Onion and cabbage. But processing cost per Kg for cabbage is higher than the cauliflower.

Dattatreya M. Kadam,[5] et.al made and conducted study on Solar Heat Collector with flat plate of forced Convection type for Drying Cauliflower, They made a closed duct covered with transparent glass sheet in which they used iron sheet of galvanized with black paint. The Four solar panels were arranged in parallel to each other and the blower will force the hot air into the drying chamber. From the study the thermal efficiency of solar heat collector can be improved by optimizing airflow rate, and drying and efficiency of drying chamber.

Thiruchelvam Thanaraj et al. [6] on their study of coconut copra processing in sun drying and CRI improved kiln drying. The Open Sun drying takes a week time. If any rainy weather persists, delays the copra drying produce fungal infection with a grey rancid product. Even then sun drying is highly labour intensive with more space requirement the direct drying associated with deposition of dirt and dust, deteriorates the quality. On contrary direct contact of smoke deposits with copra cups in kiln drying, leads to formation of polycyclic aromatic hydrocarbons makes inferior quality copra M. Mohan raj and P. Chandrasekar [7] on their experiment of copra drying using solar drier with heat storage material. and without of it. The solar flat plate inbuilt drier with sensible heat storage unit contains aluminum scrap mixed with sand, a

drying chamber and a centrifugal blower. The copra moisture content brought to 8 % from 52% in 80 hrs. For the same result without using heat storage material it takes 104 hrs. The average solar drier thermal efficiency about 23% in both drying modes.

From the literature review, the current available dryers were design and made for medium to large scale farmers group. There was a necessity to design for small and single house hold application, that too the dryer unit to work in all climatic conditions. An indirect heating technique to be used to get white copra of good quality at the minimal cost. The main objective of this work is to develop and design a small electrical dryer for an individual household or for small farmers of Tamilnadu to make high quality copra in a reliable method of processing.

The copra drying machine which can dry copra even during rainy season. Apart from coconuts, it can also be utilized for drying maize, groundnuts and other spices.

III. ENERGY USED

Most of coconut copra dryer is working with the source of direct solar energy or with solar panel with mini fans for forced circulation types, but it is not suitable for rainy season and most cloudy times. But the current design handy electrical dryer will be used even at rainy seasons.

The small blower uses the electrical energy as the main source for drying and in filament heat energy is generated when current flows through it. The effect of heating varies with important factors like conductor resistance(R), Current flow time (t), and amount of current flows (I).

A higher amount of resistance and current produces more heat. The handy electrical blower having forward, backward crosswise direction of movements and as a whole machine, it can be moved in all the four directions. The hot blower unit is moving with the help of 12v DC motor (permanent magnet DC motors). The dryer unit consists of two sections, first is base section and second one is head section, the base section is a rectangular frame, it is having four wheels, trolley for moving head arrangements and the head section is having electrical dryer with blower fans, with drive wheel arrangement.

Design Calculations

For considering 10 kg mass of coconut copra,

Heat energy required

$$= \text{mass} \times \text{Specific heat} \times \text{Temperature rise}$$

$$Q = m \times C_p \times (t_2 - t_1) = 10 \times 2.85 \times (70 - 30)$$

$$Q = 1140.025 \text{ KJ}$$

where,

Q = Heat energy required in KJ

t_1 = initial temperature of heating chamber in $^{\circ}C$

t_2 = final temperature of heating chamber in $^{\circ}C$

C_p = Specific heat of Coconut Copra KJ / kg

Power required for heater to produce this amount of energy

$$= 1140000 / 3600$$

$$= 316.66 \text{ J / sec} \approx 317 \text{ watts}$$

using Ohm's law,

$$V = I \times R$$

as per Joule's law,

$$P = I \times V$$

Where,

V = Voltage in volts,

I = Current in amperes,

R = Resistance in ohms,

P = Power in watts,

Voltage = 230 V

$$P = I \times V$$

$$I = P / V$$

$$= 317 / 230$$

$$= 1.37 \text{ A} \approx 1.5 \text{ A}$$

$$\text{Power}(P) = I \times V = 1.5 \times 230$$

$$= 345 \text{ Watts} \approx 400 \text{ Watts}$$

Considering the open hot air flow with 40% efficiency, with other losses

The Power requirement is 1000 Watts

$$\text{Resistance}(R) = V^2 / P = 230^2 / 1000 = 52.9 \Omega$$

Area of Drying unit

$$A = L \times B = 305 \times 305 = 93 \times 10^3 \text{ mm}^2$$

Diameter of heating chamber

$$D = 250 \text{ mm}$$

Area of heating chamber

$$A = \pi / 4 \times D^2 = \pi / 4 \times 250^2$$

$$A = 50 \times 10^3 \text{ mm}^2$$

Dimensions of the guidetrack vehicle

$$\text{Length} = 1985 \text{ mm}$$

$$\text{Width} = 600 \text{ mm}$$

Moisture content of copra

Using wet basis method,

$$M_{wb} = \frac{m_{wet} - m_d}{m_{wet}}$$

Where

m_{wet} = mass of the wet mcoconut in kg

m_d = mass of the dry coconut in kg

$$\text{Drying rate} = \frac{m_{water}}{t}$$

Where

m_{water} = mass of water evaporated from the wet coconut in kg

t = drying time in hrs.

Mass of water evaporated from the wet coconut

$$m_{water} = \frac{m_{wet}(M_{wbi} - M_{wbfi})}{100 - M_{wbfi}}$$

Where

M_{wbi} = initial moisture content

M_{wbfi} = final moisture content

$$m_{water} = \frac{10(52 - 6)}{100 - 6} = 4.89 \text{ kg}$$

$$\text{Drying rate} = \frac{4.89}{11} = 0.44 \text{ kg / hr} \approx 0.0001 \text{ kg / sec}$$

$$M_{wb} = \frac{10 - 4.89}{10} \times 100 = 51.1 \%$$

$$SMER = \frac{m_{wi} - m_{wo}}{Q_{tot}} = \frac{5.11}{41.6} = 0.12 \text{ kg / kWh}$$

IV. MODEL DEVELOPMENT

The following figures have shown the 2D and 3D models of the coconut copra electric dryer.

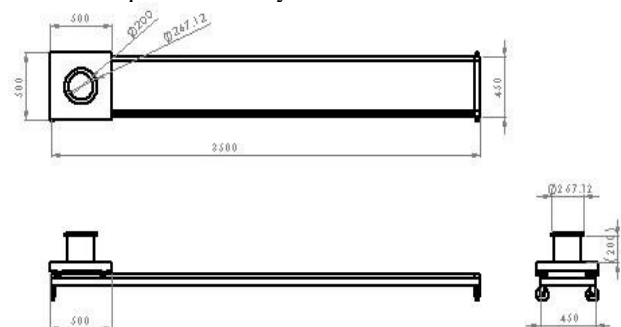


Fig.1.2D model of the Electric dryer



Fig.2. 3D model of the Electric drier



Fig.3. Side view of the Electric dryer



Fig.4. Front view of the Electric dryer



Fig.5. Close view of the Electric heater

V. GRAPHS

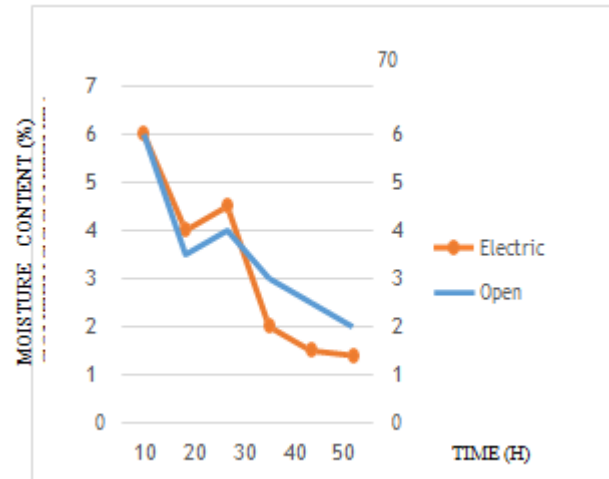


Fig.6. Comparison of Moisture content electric drying over sun drying

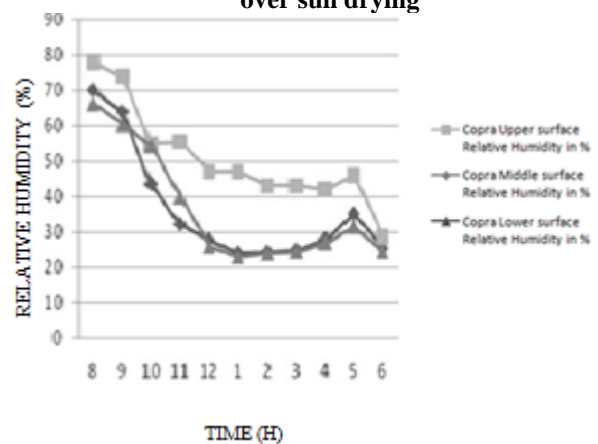


Fig.7. Variation of Relative humidity with time

VI. RESULTS

Parameter	Value, (per 10kg of Copra)
Quantity of heat needed to evaporate water, Q	1140 kJ
Power required for heater, P	1000 Watts
Resistance	52.9 Ω
Initial humidity ratio, ω_i	0.06 kg/kg
Final humidity ratio ω_f	0.015 kg/kg
Mass flow rate air, m_a	0.2265 m ³ /s
Volumetric airflow rate,	0.2265 m ³ /s
Area of the Drying unit	93x10 ³ mm ²
Area of the heating chamber	50x10 ³ mm ²
Moisture removed from the product	4.89 Kg
Final mass of the product	5.11 Kg
Drying Rate	0.0001 kg/s
Electrical energy Consumption	41.6 kWh
Specific Moisture Extraction Ratio	0.12 kg/kWh

VII. CONCLUSION

The handy electrical heat drier is designed, fabricated, and tested for copra drying. It is concluded that the quality of copra obtained in the electrical drier is graded as 92.7 per cent MCG1 and 7.4 per cent MCG2.

The drying period is considerably reduced in an electrical heat drier. The SMER of the electrical drier is estimated to be about 0.12 kg/kWh. The results showed that moisture content (wet basis) of the coconut is reduced from 52 to 6 per cent in 11 hours. The outcome quality of dried coconut is found to be good; the electric heat drying offers a suitably attractive option to improve the copra quality and reduces the fungal affection through the controlled regulations of the drying conditions. The copra color and aroma has been reported that, they are comparatively better than conventional drying methods.

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