TESTING AND EVALUATION OF COPRA PROCESSING IN SUN DRYING TECHNIQUE

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INTRODUCTION

The coconut palm is one of the most versatile trees known in view of its use as a source of food and drink, timber and shelter. The major coconut producing countries in the world mainly export the primary products such as copra, coconut oil and desiccated coconuts (Bischoff, 1996).

Sri Lanka has a total land extent of 4,39,000 ha under coconut cultivation. Over 80% of this extent is concentrated within a radius of about 50 miles, encompassing the capital and the main commercial city of Colombo. According to Anon (1999) the annual coconut production in Sri Lanka is about 2808 million nuts. Out of the total production, about 1799 million nuts were used for household consumption, extraction of coconut milk and domestic cooking. The balance of about 1000 million nuts were available annually for processing into industrial products such as coconut oil, copra and desiccated coconut both for the domestic market as well as for export. Coconut products are an important source of domestic income and a vital source of export earnings (Anon, 1999).

Traditionally drying is done either using a kiln or under direct sun. It is necessary to reduce the moisture content of the meat from about 50 % (w.b.) to 3-5 % (w.b.) in order to reduce the weight, prevent microbiological deterioration and concentrate the oil. On average, five nuts are required to produce 1 kg of copra, but this conversion rate varies (plus or minus 40%) from country to country (Patterson and Perez, 1981).

In most cases, copra produced is of inferior quality, the oil derived there from is also of poor quality and needs additional refining to meet international standards. Poor quality is subjected to an automatic price deduction of 10 to 15% in the world market or total rejection, thus resulting in annual losses of more than US$ 40 million (Dippon and Rose, 1996).

Sun drying requires little in the way of capital or expertise and that can give a product of acceptable quality in a reliable climate. However, sun drying does have many limitations such as increasing rate of spoilage during drying process due to irregular and intermittent rate of drying, final moisture content is high so spoilage during storage is high, product quality is likely to be variable, relatively larger areas of land or other surface is necessary, need of more labour and direct exposure to sunlight or more precisely ultra-violet radiation reduces the level of nutrients (Brenndorfer *et al.*, 1987).

Though direct sun drying of copra causes several disadvantages, still it has been practiced in most of the coconut producing areas. It is suspected that the unawareness of the rural public regarding these defects of direct sun drying is the main reason for this nature. Therefore, there is a necessity to test and evaluate the direct sun dying of copra and quantify the results. I hope that it may create awareness among the rural peoples and urge them to go for new improved copra drying techniques to produce quality copra.

The broad objective of this study was to test and evaluate the sun drying of coconut to test its performances regarding the quality and yield of copra. Specific objectives were comparing the evaluation results with other copra processing techniques, creating awareness among the farmers regarding the sun drying of copra and its performances, encouraging the farmers to adopt new improved copra processing techniques and improving the quality copra processing and copra processing industries in Sri Lanka.

MATERIALS AND METHODS

This experiment was conducted at the Division of Agricultural Engineering, Eastern University, Sri Lanka, Chenkalady during the period of December 2004 to January 2005.

Traditional sun drying principles were followed in this experiment. 100 coconuts (200 coconut cups) were dried in a batch. Coconuts were splitted in the early morning and the cups were drained off and spread on a black polyethylene sheet by facing upside right in one layer (Fig.1). The cups were protected from the rain and also birds like crows and animals like cats, dogs and monkey. Retention of any sap or moisture on the surface at this stage results is a gummy slime in the product. Precautions were taken to avoid adulteration with sand and other extraneous matter. Temperature sensors were fixed on the surface of the cups to record surface temperature during sun drying period. Temperature sensors were also fixed to record the ambient dry and wet bulb temperatures. A solar sensor was fixed to record the solar insolation continuously. Samples were taken at the beginning for the determination of initial moisture content. And then it was taken in the morning and evening of each day of sun drying. Cups were covered completely by polyethylene during night and rainy days.

Sun drying could be completed in 6 days. At the end of 3rd day of sun drying, the shells were removed from the cups and coconut kernels were spread on the sheet for further drying. At the end of the 6th day, it was found that the copra had dried to a sufficient moisture content based on the observation and the moisture determination results. And finally the grading was done according to the standards. The testing was repeated three times to assure the quality.

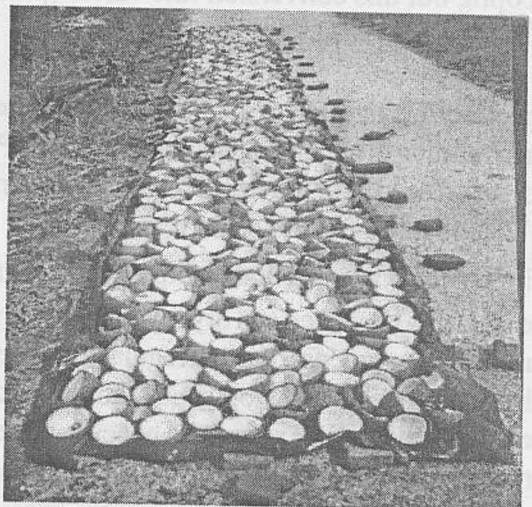


Fig. 1: Sun drying of coconut kernel

Estimation of the thermal efficiency

The thermal efficiency of the direct sun drying was estimated using the equation 1 given by Singh (1978). Total energy utilized in the drying process was considered.

$$\text{Thermal Efficiency } (h_t) = \frac{j\, l\, (M_o - M_f)}{WC\,(100 - M_o)} \times 100 \qquad (1)$$

Where, Mo = Initial moisture content of coconut (%, wet basis), M_f = Final moisture content of coconut (%, wet basis), j = Quantity of the final dried product at M_f moisture content (kg), l = Latent heat of vaporization of water in kJ/kg, W = Quantity of fuel used (kg), C = Calorific value of fuel used (kJ/kg).

INSTRUMENTATION

The operational parameters such as temperatures, relative humidity, wind velocity and solar insolation were recorded and monitored continuously. Instrumentation was done using a CR 10 data logger. About 16 channels were available in this data logger. Channels were set and programmed for temperature, solar and RH sensors. Temperature sensors were fixed on the surface of the drying coconut cups in different places of the drying batch of the coconuts.

DETERMINATION OF MOISTURE CONTENT

Seven samples were taken from randomly selected seven cups for the moisture determination in predetermined intervals. Seven samples were chopped to a composite sample and about 10 g were drawn from that and kept in a convection oven at 105 °C until a constant weight is reached. The moisture content was determined in drying coconuts once in an hour and it was plotted against time to obtain the drying curve.

GRADING OF COPRA

Grading is the sorting out of the copra as white copra, coloured copra, burnt copra, mouldy copra, quality parameters, etc based on the standards. At the end of each drying, copra was graded according to the standards (SLS 612:1983). Different grades were given in percentages (Table 1).

Table 1: Requirements for Milling Ordinary (M.O.) copra (SLS 612, 1983)

Serial number	Characteristics	Requirements			
		M.O. GI	M.O. GII	M.O. GIII	M.O. GIV
1	Moisture present by mass, maximum	10.0	10.0	10.0	10.0
2	Oil content (moisture free basis), percent by mass, minimum	68.0	68.0	68.0	68.0
3	Free Fatty Acids (as lauric acids), percent by mass, maximum	N/S	N/S	N/S	N/S
4	Impurities, present by mass, max.	N/S	N/S	N/S	N/S
5	Broken cups or chips percent by number, max. (passing through a 9.5 mm sieve)	N/S	N/S	N/S	N/S
6	Mouldy cups*, percent by count, max.	20.0	50.0	80.0	100.0
7	Lovibond colour, in a 25 mm cell, expressed as Y+5R, max.	N/S	N/S	N/S	N/S

RESULTS AND DISCUSSION

Since it was bright sunny days during the period of these trials, drying could be completed in 6 days. At the end of 3rd day of sun drying, the shells were removed from the cups, the moisture content was 19% at that time and kernels were spreaded on a polyethylene sheet for further drying. At the end of the 6th day, it was found that the copra had dried to about 10% moisture content. Lozada (1991) reported that the sun drying of copra usually takes 7 days. Poor quality copra is produced due to the inadequate drying.

The surface temperature of drying cups

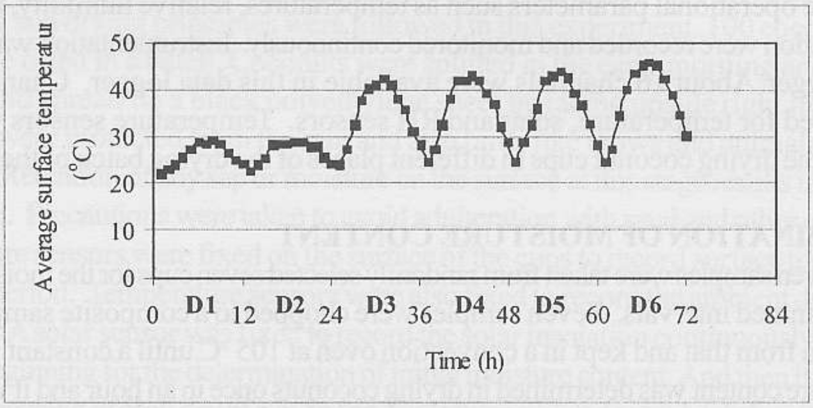


Fig. 2: The variation of surface temperatures of the drying cups with time during sun dying. D1 to D 6 – sun dying trial day1 to day 6

For first 2 days, the maximum temperature was below 30 °C then it increased with time. The presence of surface moisture and the higher moisture migration rate might be the reason for the lower surface temperature during first two days. The surface temperature of the drying coconut cups varied between 46 °C and 22 °C with the mean value of 33 °C (Fig. 2). The secret of white copra is the lower drying temperature than other dryer.

The higher surface temperature was recorded at the noontime of the day. The literature shows that the surface temperature is ideal for the production of good quality copra. Anon (1965) reported that the maximum surface temperature recorded on the copra when being sun dried in the open was 40 °C. This is well below the critical temperature of 70 °C, above which copra is inferior in quality. Thampan (1981) reported that if the climate is favourable, it is possible to get good quality copra by sun drying with the minimum operational cost. The method does not require any particular skill either, because the surface temperature of the cups rarely exceeds 40 to 42 °C in most of the copra producing countries. At this temperature, no undesirable changes affect the quality of the final product.

However, a discolouration of kernels possibly due to microbes was observed during these sun drying trials. This was prominent in immature coconuts, their drying rate was relatively low and moisture content to be high.

CLIMATIC PARAMETERS DURING THE DRYING PERIOD

The average dry and wet bulb ambient temperatures recorded were 28 °C and 21 °C respectively. The average relative humidity was 79%. The cup surface temperature was 46 °C, which was about 16 °C higher than the ambient temperature (Table 2). This value was little higher than the value reported by Thampan (1981).

Table 2: Climatic conditions during the drying period of sun drying

Atmospheric recording	Highest	Lowest	Average
Ambient Temp. (d.b.) °C	29	26	28
Ambient Temp. (w.b.) °C	22	20	21
RH (%)	84	74	79
Solar Insolation (W/m^2)	834	15	426

The average solar insolation was recorded as 426 W/m^2. However, it was within the range of 15 W/m^2 to 834 W/m^2. It was observed that these days were not clear sunny days although the climatic conditions were conducive for sun drying (Fig. 3).

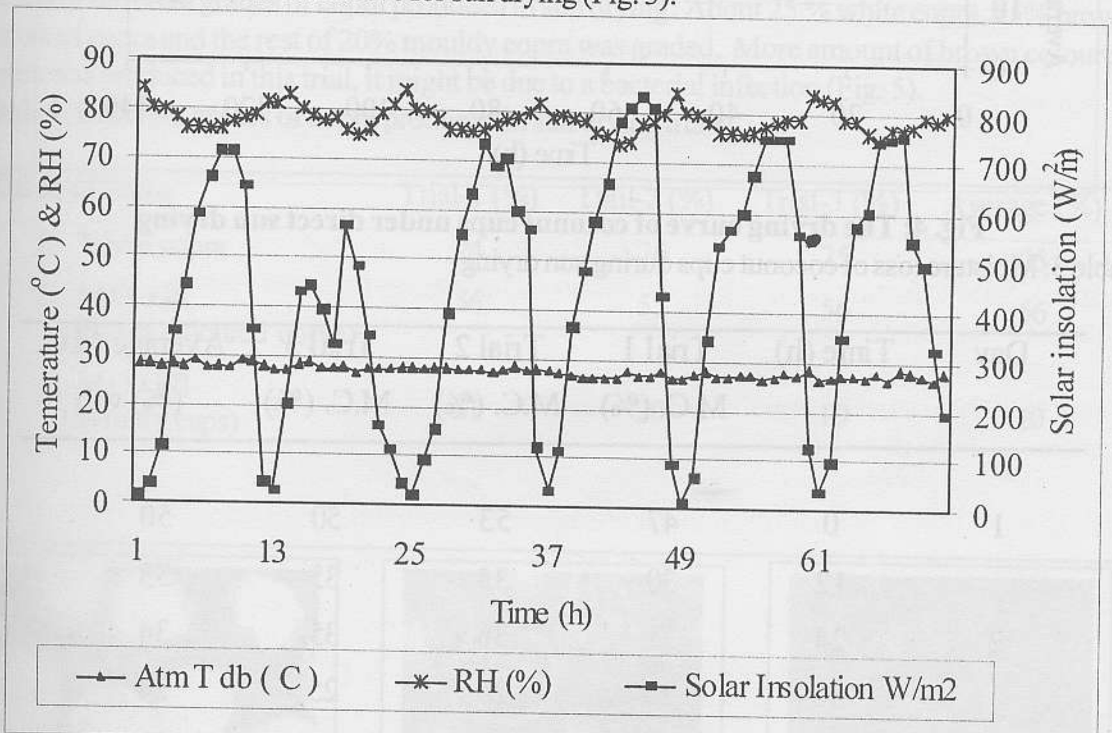


Fig. 3: Variation of solar insolation, ambient temperature and RH during sun drying
D1 to D6 – sun drying trial day 1 to day 6

DRYING BEHAVIOUR OF COCONUT

The average initial moisture content of coconuts was determined as 50% and it was reduced to 10% at the end of 6th day under direct sun drying (Fig. 4 and Table 3). During the first 3 days, moisture removal rate was relatively high; 16%, 9% and 6% during the first second and third days respectively. However, the moisture content increased by 1-2% during the night due to desorption, and also the drying curve follows the similar pattern of the common drying curve of coconut (Fig.4). Thereafter, the moisture removal rate decreased to about 4 -2%, because the increased resistance to moisture migration from the deeper layers of the kernel to the surface (Table 3). It should be further dried to the moisture content of around 6% for better storage life. Anon (1965) reported that the sun-dried copra gives a final product of 10-15% moisture, which is too high to avoid deterioration. In certain parts of India and Sri Lanka, the moisture is found to be 8-10% and during storage further reduction to 5 or 6% takes place. In this manner, good quality sun dried white copra is produced in these two countries in some areas where the climate is suitable for sun drying.

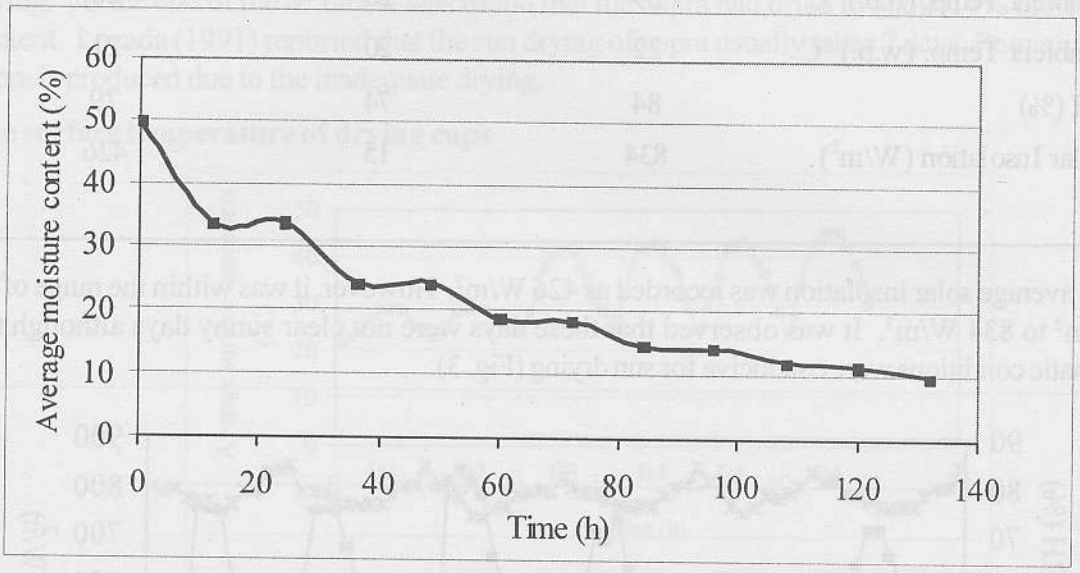


Fig. 4: The drying curve of coconut cups under direct sun drying

Table 3: Moisture loss of coconut cups during sun drying

Day	Time (h)	Trial 1 M.C. (%)	Trial 2 M.C. (%)	Trial 3 M.C. (%)	Average M.C. (%) w.b
1	0	47	53	50	50
	12	30	35	35	33
2	24	31	36	35	34
	36	22	25	25	24
3	48	23	25	25	24
	60	18	20	19	19
4	72	18	20	19	19
	84	15	15	14	15
5	96	15	15	14	14
	108	12	12	11	12
6	120	12	12	11	12
	132	10	11	9	10

THERMAL EFFICIENCY UNDER SUN DRYING

About 153 kg of copra produced from 700 nuts weighing about 350 kg of fresh cups in each sun dying trial. The total moisture removed per trial was 109 kg. It was reported about 1800 kg wet kernel is needed to produce 1000 kg copra on the basis of moisture content of 50% in the kernel when fresh and 10% after sun drying (Anon, 1965). Prolonged dry weather during growth of coconut reduces the size of the nut and kernel and hence requires many more nuts per tonne of copra.

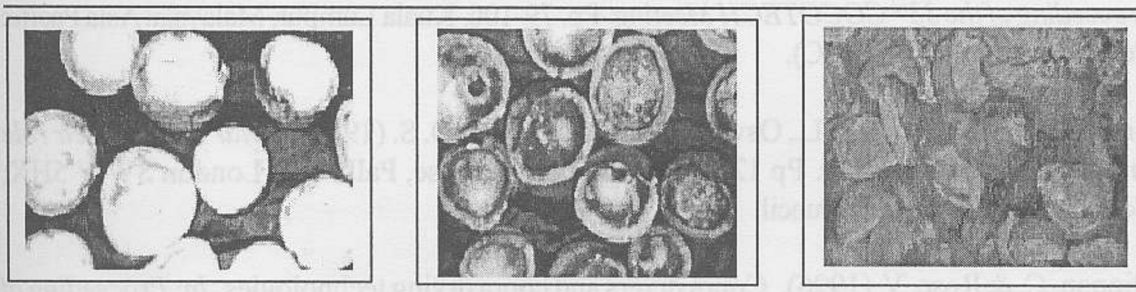
The thermal efficiency of sun drying was 23% using the equation (1). The thermal efficiency was relatively higher than that of solar hybrid drying and CRI improved kiln drying techniques, where thermal efficiency of solar hybrid drying was 10 % and CRI kiln drying was 15.5 %, respectively (Thanaraj et al., 2004).

COPRA QUALITY

The dried copra was graded based on the SLS standards 612:1983. Table 4 indicates the details of different grades of copra produced in sun drying. About 25 % white copra, 55% brown coloured copra and the rest of 20% mouldy copra was graded. More amount of brown coloured copra was produced in this trial, it might be due to a bacterial infection (Fig. 5).

Table 4: Different grades of copra produced in sun drying trials

Grade of copra	Trial-1 (%)	Trail-2 (%)	Trial-3 (%)	Average (%)
1. White copra	24	26	25	25
2. M.O. GII (Brown coloured copra)	56	55	56	56
3. M.O.GIII (Mouldy cups)	21	20	19	20



a) White copra (b) Brown copra (c) Mouldy copra

Fig. 5: Different grades of copra processed in sun drying

Only about 25% of white copra was produced in these trials and it is clear that sun drying is not an ideal method for the production of high quality white copra. The cups were dried for six consecutive days and it is comparatively a long period. Therefore, indirect copra drying within a short period is preferred to produce high quality white copra by minimizing the microbial spoilage. Lozada (1991) reported that to enable the farmers to make copra more quickly, the use of drying kilns are resorted. The most common drying kilns are of the direct-fired type where the products of combustion come in contact with the copra being processed. Anon (1965) reported that copra manufacture solely by sun drying can be effective only in coconut regions with long periods of sunny clear skies, high mid-day temperatures (30 to 35 °C in the shade) and low humidity air (60 to 70% RH). In regions where very humid air is prevalent most of the time, though sun drying is practiced, it is ineffective and spoilage is common.

CONCLUSIONS

The following conclusions were drawn from this study,

i. The average temperature at the surface of drying cups was 33 ° with a maximum of 46 °C, that is below the optimum level of 60 °C.

ii. The thermal efficiency of sun drying technique was 23 %, it was relatively higher than that of other drying techniques.

iii. Comparatively lengthy period (6 days) was taken to process copra to the final moisture content of 10 %. Drying the coconut in lengthy period may cause several disadvantage, practical problems and extra workload.

iv. The copra processed under this technique was graded as 25 % white copra, 55 % M.O.GII copra and 20 % M.O.GIII copra.

v. Less amount of white copra processed compare to other indirect drying techniques. It might be due to the bacterial infestation and contamination of foreign materials during the drying process.

REFERENCES

Anon. (1965). *How to Make a Solar Cabinet Dryer for Agricultural Produce.* Pp. 9. A do it yourself leaflet. Saint Anne de Bellevue, Canada: Lo Brace Research Institute.

Anon. (1999). Export potential of plantation crops. *Annual Report*. Pp 10-25. Central Bank. Sri Lanka.

Bischoff, J. (1996). Technology transfer and applications in relation to the coconut industry. In: *Proceeding of the 33rd COCOTECH Meeting.* Pp. 79-106. Kuala Lumpur, Malaysia: Asia Pacific Coconut Community (APCC).

Brenndorfer, B., Kennedy, L., Oswin, B. C. O. and Trim, D. S. (1987). *Solar dryers -their role in post harvest processing.* Pp 12-50. Marlborough House, Pall Mall, London SWIY 5HX: Commonwealth Science Council.

Dippon, C. & Rose, V. (1996). Copra dryers and copra drying technologies. *In*: *Proceeding of the 33rd COCOTECH Meeting.* Pp. 79-106. Kuala Lumpur, Malaysia: Asia Pacific Coconut Community (APCC).

Lozada, E. P. (1991). Copra making and small scale cooking oil production systems. In: *Proceeding of the 28th COCOTECH Meeting.* Pp. 320 - 342. Chiangmai, Thailand: Asia Pacific Coconut Community (APCC).

Patterson, G. & Perez, P. (1981). *Solar Drying in the Tropics*. Pp.13. Santa Monica, USA: Meals for Million of Freedom from Hunger Foundation.

Thampan, P. K. (1981). Food products and commercial products. In: *Handbook on Coconut Palm*. New Delhi. Pp 195 – 276: Oxford and IBH Publishing Co. Pvt. Ltd.

Thanaraj. T., Dharmasena. D. A. N. and Samarajeewa. U. (2004). Design and fabrication of an improved solar hybrid dryer for small scale copra processing. *M.Phil thesis*. Pp 50-70: Postgraduate Institute of Agriculture (PGIA), University of Peradeniya.

Tillekeratne, A. (1991). Small scale processing of copra and coconut oil in Sri Lanka. In: *Proceedings of the 28th COCOTECH Meeting*. Pp. 300-317. Chiangmai, Thailand: Asia Pacific Coconut Community (APCC).