

EVALUATION OF WEATHER DATA FOR DRYING AND STORAGE OF COPRA

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ABSTRACT

Weather data such as mean daily temperature, relative humidity, wind velocity, sunshine hours and rainfall per meteorological week at Kasaragod (HT MSL - 10.7 m 12.30'N Latitude and 75°E Longitude) were evaluated for predicting suitable drying period and safe storage period. Equilibrium moisture content of copra at all meteorological weeks was determined. The time required for drying was calculated per week from the energy associated with ambient air. The copra can be dried from 40th week to 20th week within 8 days. Drying can be achieved within 6 days if dried during 13th to 19th week. Drying can be achieved even during 40th to 48th week and 21st to 22nd week if solar cabinet drier is used, because during this period precipitation over 25 mm/week is expected. During the predicted suitable drying period solar radiation available is in the order of 5000 k Cal/m /day and hence drying process can be accelerated by trapping this energy by use of solar drier. Copra can be stored safely in well ventilated storage structures except in 25th to 39th week, relative humidity being below 80%. If proper ventilation is not maintained it may deteriorate even from 22nd week. From 22nd to 41st week the relative humidity ranges between 80-90% and equilibrium moisture content of copra above 4% which attracts fungus *Penicillium frequentans*. To avoid this, supplemental heat aeration (5°C above ambient) or use of industrial dessicants may be practised in storage structure.

INTRODUCTION

Copra is the dried kernel of coconut. Good quality copra shall has a moisture content of around 6%. The initial moisture content of kernel being 45-50% (w.b.), sundrying is usually practised and mechanical drying is opted only when indispensable. The time required for sundrying mainly depends on ambient air conditions. It takes about 5-7 days if drying is carried out on bright sunny days. If drying is slow as in humid weather the

spoilage by microbial infection is more pronounced. If after cutting open the nut, the drying is delayed, even by few hours spoilage sets in affecting the quality of oil (Grimwood, 1974).

India produces about 5800 million nuts per year and copra production is about 327000 tonnes (Nair and Mathan, 1971). The energy needed for preparing the above quantity of copra would be about 176580×10^6 KCal. Fortunately, being in tropics there is plentiful supply of solar energy by diffusion as well as radiation. So it is upto processors to use the naturally available energy to the fullest extent.

Coconut kernel is an excellent substrate for the growth of fungi and bacteria. The infestation can occur at all levels of moisture content, unless proper preventive measures are not adopted. Copra was observed to be infested even at 4 percent moisture content when humid condition above 85% relative humidity prevail (Henderson, 1952).

This shows that both the drying and storage of copra are closely related to ambient conditions. Knowledge of prevailing ambient conditions at any given time of the year will enable to pre assess the moisture content upto which copra can be dried, the time required for drying and the extent of supplemental aeration needed for safe storage. Such information will help in appropriate drying and storage systems, design and planning.

MATERIAL AND METHODS

Weather data for 11 years (1969-1979) viz. temperature, relative humidity, wind velocity, sunshine hours and rainfall were collected from the agricultural meteorological observatory at CPCRI Kasaragod situated 10.7 m above mean sea level, 12.5°N latitude and 75°E longitude. The average values of all these parameters over 11 years were calculated for every meteorological work. The material constants C and N in Henderson's Equation (Equation No. 1) for equilibrium moisture curve were calculated from the data after Brustillos and Banzon (1949) (Table 1).

$$1 - RH = C - CTMe^n - (1)$$

Equilibrium moisture content values of copra for every met week were calculated from mean temperature and relative humidity values by equation 1. The drying day degree were calculated equal to wet bulb depression at known mean temperature and relative humidity values (Perry, 1950). The energy available with ambient air which could be used for drying at 100% efficiency was calculated by following equation.

$$E = S.W.C_p.Q.DD \quad \text{---(2)}$$

where

E = energy in KCal/m²/day

S = no. of sunshine hrs. per day

W = wind velocity in m/hr

C_p = Specific heat of ambient air

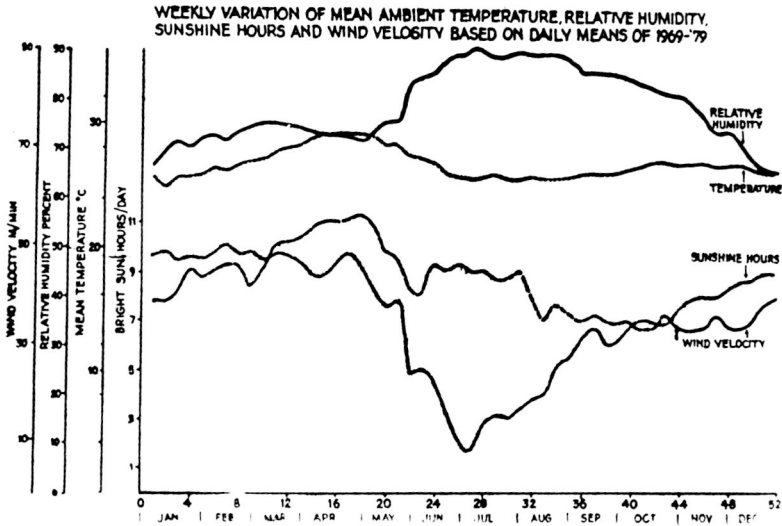
Q = density of air from humid volume at corresponding mean temperature

DD = No. of drying day degree/day

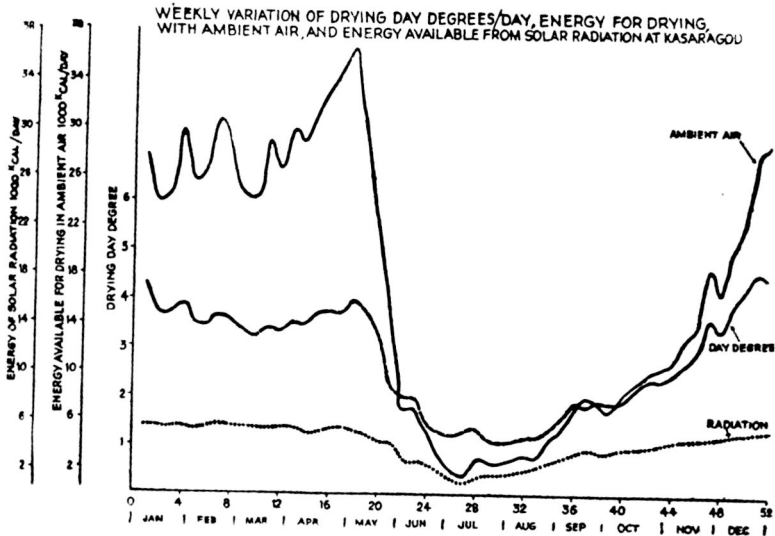
The copra is generally spread in a single layer at about 70–80 cups/m² yielding about 6 kg of copra. The moisture thus to be removed will be $6 \times 0.9 = 5.4$ kg. Considering energy required for vapourization as 600 KCal/kg of water, the total energy required for drying will be $600 \times 3.4 = 3240$ KCal. The time required for drying was calculated by assuming the heat utilization efficiency of natural drying at 1.75%. The energy available from solar radiation which was calculated from the average global radiation at Kasaragod which is in the order of 570 KCal/m²/day.

RESULTS AND DISCUSSION

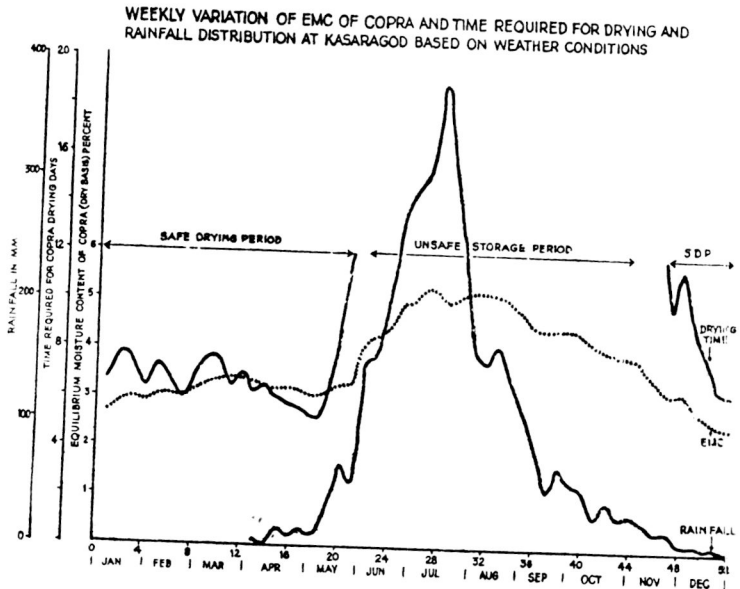
Fig. 1 shows the variation of mean temperature, relative humidity wind velocity and sunshine hours at different meteorological weeks. Fig. 2 shows variation of drying day degrees per day and energy associated with ambient air/day for drying and energy available from solar radiation/day. Fig. 3 shows the variation in equilibrium moisture content of copra, number of days required for drying and rainfall/week. The best suited period for drying and safe storage period are also marked on Fig. 3. Every point on the graph is average of 11 years.



(Figure 1)



(Figure 2)



(Figure 3)

Variation of weather parameters with line

Temperature: The mean temperature was obtained by the average of daily maximum and minimum temperature. The higher values above 28°C occur during 14th to 22nd week (April and May) and lower values of about 26°C prevail during 27th to 35th week (July, August). The average daily temperature over 52 weeks is 26.6°C . Drying under these conditions, being low temperature will not have any adverse effect on quality of copra.

Relative humidity: The higher values above 85% occur during 23rd to 29th week (June to September) and lower values below 70% occur during 49th to 5th week (December to January). The average relative humidity for 52 weeks is 78%.

December and January having relative humidity below 70% are most suited for hot air drying from drying efficiency point of view.

Wind Velocity: The higher values above 50 m/min occur from 13th to 19th week (last week of March to first week of May) which

directly helps in quicker drying. The lower values below 35 m/min are observed during 40th to 50th week (October, November and first fortnight of December). The average wind velocity is 41m/min are observed during 40th to 50th week. The wind velocity throughout the year is well above the required value in thin layer drying.

Sunshine hours: The bright sunshine hours above 9.5 occur during 1st to 11th week (January to mid March) and sunshine hours less than 3.5 occur from 25th to 31st (from second week of June and July). The no. of sunshine hours are lower during cloudy weather in rainy months which reduces the availability of energy from solar radiation. The average sunshine hours per day at Kasaragod are 7.2 hr/day.

Rainfall: From 22nd to 35th week (last week of May to August) this place receives rainfall above 100 mm/week. It results in increase in vapour content of the air, hence reduction in drying ability of the ambient air. Clear dry weeks are 1st to 9th (January-February). Peak rainfall is in 24th week (second week of June). Rainfall above 25 mm/week is also received during 19th to 22nd week and 36th to 44th week (May, September and October).

Equilibrium Moisture content of copra

The material constant C and N for copra are 1.22×10^{-3} and 1.10 respectively. The equilibrium moisture content values calculated by putting the values of C, N, T and RH in equation 1 remained below 6% throughout the year. This indicates the possibility of drying copra upto desired level even only by aeration. It also indicates the moisture level which well dried copra would attain if stored for long duration. The average value of equilibrium moisture content is 3.8%. This value is observed to be increased beyond 4% mainly due to the effect of relative humidity of the ambient air, i.e. when the relative humidity is above 80% in 23rd to 44th week (June to October).

Energy associated with ambient air for drying

The higher energy values of above 30,000 Kcal/m²/day occur during 13th to 19th week (first week of March, April and first week of May) resulting in the drying of copra within 6 days. The lower

energy values occur during 27th to 44th (July to October) i.e. more than 20 days for drying. The energy associated with ambient air is function of five factors given in equation no. 2. Out of them wind velocity, drying day degrees and no. of sunshine hours are most prominent factors. More energy available during 11th to 19th week (March second week to first week of May) is due to higher wind velocity and no. of sunshine hrs and energy during 49th to 5th week (December and January) is the function of higher drying day degrees and no. of sunshine hours.

Energy available from solar radiation

About 8 months, there is plentiful supply of solar radiation. The energy available is above 4000 Kcal/m²/day from 40th to 21st week (October to third week of May). This helps in quickening the drying process along with the energy associated with ambient air for drying. This is function of no. of bright sunshine hours per day and offers the scope for the use of solar driers. The lower value of solar radiation occur during 23rd to 35th week (June to August). Average solar radiation for 52 weeks is about 4100 Kcal/m²/day.

Effect of weather on drying of copra

The peak harvest season of coconut which comes in March offers advantage in use of most effective time for drying in the year i.e. 13th to 19th week (last week of March to first week of May). The time required for drying is only 6 days to obtain good quality copra, as shorter the drying period results in better quality copra. The drying should not be practised from June to September because of heavy rainfall and high humidity in the air. Artificial drying during the period also will not be much economical due to less moisture carrying capacity of the air. Suitable drying period for copra under the sun is from 49th to 20th week (December to second week of May) where copra can be dried within 9 days. Bright sunshine hours and wind velocity which are conducive to drying are observed to increase from December to May. During December and January drying is quicker due to higher day degrees i.e. above 4. This period is also best suited for mechanical drying due to lower relative humidity of ambient air (about 70%). Quicker drying is also achieved during 13th to 19th week due to higher

value of wind velocity i.e. above 55 m/min. The drying time of about 18 to 20 days is required during 40th to 48th and 21st and 22nd week (October, November and Second fortnight of May) which can be reduced to 10 to 12 days by utilizing radiant energy with the help of solar drier. During this period light showers are also received which makes sundrying without solar drier little risky. Solar driers used for drying copra in combination to open drying throughout the suitable period (October to May) will help in quicker drying of copra.

Table 2. Weather Data at Kasaragod

(average of 11 years)

<i>Met week</i>	<i>Mean Temp. °C</i>	<i>Relative humidity%</i>	<i>Sunshine hours</i>	<i>Wind velocity m/min</i>	<i>Rainfall mm/week</i>
1	2	3	4	5	5
1	25.7	66	9.6	38.5	—
2	24.5	69	9.8	38.3	—
3	25.5	71	9.4	40	—
4	25.7	69	9.6	45	—
5	25.7	72	9.5	43.3	—
6	26.3	72	9.7	45	—
7	26.1	71	10.1	46.7	—
8	16.5	73	9.7	47.7	—
9	26.8	74	9.8	41.7	—
10	27.0	75	9.4	45	1.25
11	2.6	75	9.7	50	—
12	27.9	75	9.6	48.3	0.3
13	28.1	74	9.4	51.7	4.6
14	28.7	73	8.8	53.3	0.22
15	28.9	73	8.8	55	13.6
16	28.9	73	9.3	55	7.9
17	29.1	72	9.7	55	13.5
18	29.0	71	9.2	56.7	8.9
19	28.9	73	8.5	55	31.3

1	2	3	4	5	6
20	28.2	75	7.5	48.3	66
21	28.2	75	7.9	48.3	50
22	27.2	83	4.8	41.7	151.1
23	27.0	84	5.1	40.0	156.7
24	26.6	85	4.8	46.7	201.2
25	25.8	88	3.5	45.0	274.3
26	25.7	88	2.2	46.7	232.9
27	25.4	90	1.6	45.0	305.9
28	25.5	89	2.9	45	380
29	25.8	88	3.3	34.3	255.3
30	25.3	89	3.0	43.3	253.3
31	25.5	89	3.3	45.5	156.4
32	25.6	89	3.9	40	150.6
33	25.4	89	4.0	35	166.7
34	25.5	89	5.2	38.3	137.8
35	25.5	87	5.5	36.7	11.34
36	25.9	85	6.2	35	86.1
37	26	85	6.8	36	46.1
38	25.9	85	6.0	35	68.6
39	26.2	85	6.1	35	55.8
40	26.3	84	6.8	33.3	27.7
41	26.5	83	7.1	33.3	38.9
42	26.8	82	6.9	36.7	29.3
43	26.7	81	6.9	33.3	32.4
44	26.6	81	7.6	33.3	24.9
45	26.7	70	7.9	33.3	16.5
46	26.9	76	8.1	36.7	18.2
47	26.6	73	8.0	33.3	7.85
48	26.5	74	8.3	33.3	7.85
49	26.7	70	8.7	33.3	7.04
50	26.4	68	8.7	35.0	5.12
51	26.2	65	9.1	38.3	3.63
52	26.1	65	9.0	40.0	0.63
Average	26.6	78	7.2	41	69.49

Table 3. Evaluation of Weather Parameters

<i>Met week</i>	<i>Drying day degrees</i>	<i>Energy associated with and air KCal/day</i>	<i>Solar radiation KCal/day</i>	<i>Equilibrium moisture content % of copra</i>	<i>No. of days required for drying</i>
1	2	3	4	5	6
1	4.3	28000	5500	2.68	6.6
2	3.7	24000	5600	2.90	7.8
3	3.7	24000	5400	3.04	7.6
4	3.9	30000	5500	2.89	6.3
5	3.5	25000	54000	3.12	7.3
6	3.5	27000	5500	3.11	6.9
7	3.7	31000	5800	3.03	6.0
8	3.5	28000	5500	3.19	6.6
9	3.4	25000	5600	3.27	7.6
10	3.2	24000	5400	3.36	7.7
11	3.4	29000	5500	3.35	6.5
12	3.3	37000	5500	3.35	6.9
14	3.5	29000	5000	3.17	6.5
15	3.7	31000	5000	3.17	5.9
16	3.7	33000	5300	3.17	5.6
17	3.7	34000	5500	3.08	5.4
18	4.0	36000	5300	3.00	5.1
19	3.7	30000	4900	3.17	6.1
20	3.4	22000	4300	3.26	8.6
21	2.2	15000	4500	3.26	12.6
22	2.0	7000	2700	41.9	26
23	2.0	7000	2900	4.32	25.5
24	1.4	6000	2700	4.47	33.3
25	1.3	4000	2000	4.96	51
26	1.2	2000	1300	4.96	35
27	1.3	2000	9000	5.35	120
28	1.4	3000	1700	5.15	62
29	1.1	3000	1900	4.96	66
30	1.1	3000	1700	5.15	75

1	2	3	4	5	6
31	1.1	3000	1900	5.15	64
32	1.2	3000	2200	5.15	56
33	1.2	3000	2200	5.15	62
34	1.3	5000	1000	4.79	35
35	1.5	5000	3310	4.79	45
36	1.9	7000	3500	4.48	25
37	1.8	8000	3900	4.48	23
38	1.9	7000	3500	4.48	26
39	1.8	7000	3900	4.47	27
40	1.9	8000	3000	4.33	23
41	2.1	9000	4000	4.20	21
42	2.4	10000	4400	4.07	19
43	2.3	10000	4000	3.96	18
44	2.4	11000	4300	30.9	17
45	2.7	13000.	4500	3.74	14.6
46	2.9	15000	4600	3.95	13
47	3.6	19000	4600	3.19	9.9
48	3.3	16000	4700	3.27	11.5
49	3.9	20000	5000	2.95	9.3
50	4.2	29000	5000	2.81	8.2
51	4.6	28000	9200	2.61	6.6
52	4.5	28000	5100	2.61	6.5
Average	2.73	17000	4100	3.8	

Effect of weather on storage of copra

Copra can be stored well except from 22nd to 44th week (last week of May to October), the relative humidity during this period being above 80%. The storage can be safe during October if structure is well ventilated. But in well ventialed structures also copra can not be stored during 23rd to 39th week (June to September) unless and otherwise some measures are adopted to reduce the relative humidity of the air inside the structure. The relative humidity above 85% during this period in combination with equilibrium moisture above 4% creates favourable condition for the infection by fungus *Penicillium frequentas*. This can be avoided

by use of industrial dessicants or by frequent aeration with supplemental hot air in the storage structures.

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