

PRODUCT APPLICATION NOTES



## Aagun®: Dryer with 24x7 consistent drying

India is one among the largest producers of vegetables, fruits, pulses, root and tube crops and many other. The Central Institute of Post-Harvest Engineering and Technology (CIPHET), Ludhiana has estimated the annual value of harvest and post-harvest losses of major agricultural produces at the national level to be of the order of Rs. 92,651 Crores calculated using production data of FY 2012-13 at 2014 wholesale prices. Estimated total loss of fruits is 15.88%, vegetables 12.44%, oil seeds 9.96%, Pulses 8.41% and cereals 5.99%. Every year large quantities of the agricultural produce gets spoilt due to insufficient food processing capabilities and inadequate infrastructure. To curb the losses in post harvesting procedures, drying is an efficient way of reducing weight and volume.

Drying is a food preservation method which is performed right after harvest or at the time of peak harvest when local markets are saturated. Drying aids in easier transportation and longer storage times for perishable vegetables and fruits. The dried and preserved vegetables market of India is expected to grow at a CAGR of 16% by the year 2020. The supportive agro-climatic conditions, potential domestic market, cost competitiveness, and government support are some of the key factors which will drive the growth of this industry.

As per experimental observations and analysis, most agricultural products require temperature in the range of 45–60°C for efficacious drying. Fruits, vegetables, herbs, fish, meat and other eatables, when dried under controlled temperature results in the enhancement of the texture and quality of the dried product. Further, indirect solar drying has many advantages over conventional methods of drying. In a closed environment the products are protected against flies, rain and dust.

Phase Change Material (PCM) integrated with solar drying offers an advantage of 24×7 consistent drying. PCMs are chemicals which enable energy storage during sunshine hours in the form of latent heat. Efficient system design of 'Aagun® – the PCM integrated solar dryer' allows storage of solar energy in the PCM which gets harnessed during non-sunshine hours. The latent heat of these materials is typically 100 times the specific heat enabling large amount of energy storage in relatively small spaces. The dryer has fans to enable good circulation and also to exhaust the moisture.



Aagun®: A PLUSS® Dryer (L) Tomatoes and Bananas after solar drying (R)

## Advantages of Aagun®

- Continuous 24/7 drying operation with significantly higher drying efficiency.
- Drying duration is one-fourth of the conventional solar dryers resulting in reduced food wastage enabling higher farm productivity.
- Better quality dried product with higher nutritional value, aroma and taste due to controlled drying with no temperature fluctuations.
- Reduced capital cost per unit of dried product resulting in a shorter payback period and higher profits.
- Maximises system productivity leading to efficient resource utilization and a reduced carbon foot print.

## Dryer efficiency

Efficiency of any machinery is defined as the ratio of Output/Input. Dryer stands out from regular machines available and the method used to calculate its efficiency. Although dryer runs for 24 hours, its input energy is fed only for 8 hours. Integration of PCM with the conventional dryers, allows storage of input energy in the form of latent heat and specific heat. However, output is achievable throughout the day. Hence **input energy** is calculated by taking solar insolation data, measured using pyranometer. Evacuated tube collectors are known to be 70% efficient in full sunshine hours. The two parameters have been taken into account for input energy calculations. To obtain **output energy**, total amount of water which can be evaporated from vegetables in 24 hours, has been considered. As a reference, for tomatoes dried in the dryer, 95% of bound water evaporated in 24 hours.

## Specifications for ~15 kg capacity PCM dryer

<b>Floor area occupied (m<sup>2</sup>)</b>	<b>3.9</b>
<b>Gross weight of the system (kg)</b>	-200
<b>Maximum Temperature for drying (°C)</b>	75
<b>Effective Heat Transfer Area (m<sup>2</sup>)</b>	3.3
<b>Efficiency (%)</b>	45*
<b>Loading Capacity(kg)</b>	See below Table below
<b>Drying duration (hours)</b>	As per individual vegetable/fruits
<b>Fan power Rating (W)</b>	0.8
<b>Total number of Fans</b>	4

\* Efficiency varies with food products. Tomatoes have 95% water content which makes it highest water containing vegetable amongst others.

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Food Product	Product/sqm (kg)	Loading capacity (kg)	Water fraction	Water content (kg)	Drying duration (hours)*	Achievable Loading/day
Tomato	6.25	13.5	0.95	12.8	24	1.00
Banana	8.33	18.0	0.75	13.5	30	0.80
Bitter Gourd	7.08	15.3	0.92	14.1	16	1.50
Indian Gooseberry	4.17	9.0	0.84	7.6	25	0.96
Onion	5.00	10.8	0.85	9.2	12	2.00
Ginger	6.67	14.4	0.86	12.4	22	1.09
Green chilli	7.08	15.3	0.90	13.8	18	1.33
Papaya	3.01	6.5	0.85	5.52	17	0.70
Pineapple	4.13	8.9	0.81	7.23	48 – 144	2 – 6
Apple	5.00	10.8	0.80	8.64	30	0.80
Mushroom	4.48	9.6	0.75	2.35	29	0.80
Carrot	2.70	5.8	0.80	4.64	48	0.5
Garlic	2.70	5.8	0.80	4.64	48	0.5
Fenugreek	1.67	3.6	0.86	3.1	21	1.14
Coriander	0.80	1.7	0.83	1.42	25	0.96
Rose	0.97	2.1	0.86	1.80	22	1.09
Spinach	2.08	4.4	0.89	3.98	25	0.96

\* Drying duration varies according to location, season and thickness of product slices.

### Drying capacity for fruits and vegetables

Data recorded for one such vegetable is shown in Figure 2. Temperature range in which PCM melts and temperature profile inside the drying chamber has been compared with the ambient temperature.

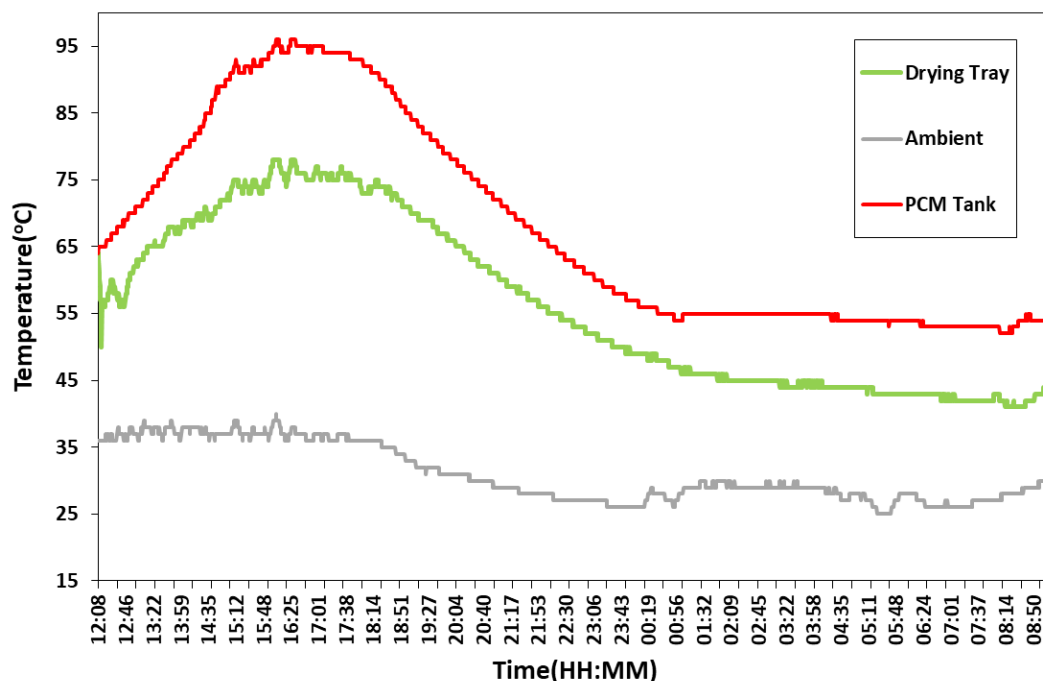


Figure 1: Temperature distribution across the Dryer

Region-wise drying temperature required for fruits and vegetables (India)

	Product	Drying Temperature (°C)	Harvesting month	Region
<b>FRUITS</b>	Mango	45 - 50	Mar-May	Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar
	Guava	45 - 50	Aug, Nov-Dec, Mar-Apr	Madhya Pradesh, Bihar, Andhra Pradesh, Uttar Pradesh, Gujarat
	Apple	45	Aug-Oct	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Uttarakhand
	Pineapple	45	July-Sep	West Bengal, Kerala, Karnataka, Bihar, Goa, Maharashtra
	Black Grapes	45 - 50	Nov-Dec, Jun-Jul	Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Mizoram
	Banana	50	Round the year	Gujarat, Maharashtra, Arunachal Pradesh, Manipur, Assam, Rajasthan, Orissa, Tripura
	Chikoo	45 - 50	Nov-Dec, Apr-May	Karnataka, Gujarat
	Gooseberries	45 - 50	Oct-Dec	Uttar Pradesh, Rajasthan, Maharashtra
<b>VEGETABLES</b>	Carrot	45	Jul-Feb	Haryana, Andhra Pradesh, Uttar Pradesh, Assam, Punjab
	Green Chilly	45	Nov-Jan	Andhra Pradesh, Karnataka, Orissa, West Bengal, Maharashtra, Rajasthan, Uttarakhand

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	Red Chilly	45	Nov-Jan	Andhra Pradesh, Maharashtra, Karnataka, Madhya Pradesh, Assam
	Mushroom	40	In controlled conditions throughout the year	Uttar Pradesh, Punjab, Haryana, Himachal Pradesh
	Onion	40	Apr-May (60%), Jan-Feb (20%), Oct-Nov (20%)	Maharashtra, Karnataka, Madhya Pradesh, Bihar, Andhra Pradesh, Rajasthan, Haryana
	Bitter Gourd	45	May-Jul	Andhra Pradesh, Orissa, Bihar, Chhattisgarh, Madhya Pradesh
	Potato	65	May-Jul	Uttar Pradesh, Gujarat, Orissa, West Bengal, Bihar
	Tomato	55	Nov-Jan	Uttar Pradesh, Himachal Pradesh, Punjab, Haryana, Rajasthan, Bihar
<b>HERBS</b>	Coriander Leaves	45	Jun-Jul, Oct-Nov	Rajasthan, Uttar Pradesh, Uttarakhand
	Fenugreek Leaves	45	Feb-Mar	Rajasthan, Uttar Pradesh, Gujarat
	Curry Leaves	45	Feb-May	Kerala, Tamil Nadu, Karnataka
	Mint Leaves	45	Jun, Oct	Uttar Pradesh, Punjab, Haryana

	Product	Drying Temperature (°C)	Harvesting month	Region
<b>MISCELLANEOUS</b>	Ginger	50	Aug-Sep	Andhra Pradesh, Karnataka, Kerala, MP, Meghalaya, Orissa, Arunachal Pradesh
	Garlic	50	Oct-Nov	Haryana, MP, Maharashtra, Orissa, Uttar Pradesh, Gujarat, Karnataka
	Rose	35	Apr-May	Karnataka, Tamil Nadu and Andhra Pradesh, West Bengal, Maharashtra
	Turmeric	45 - 50	Jan-Mar	Andhra Pradesh, Karnataka, Orissa, Tamil Nadu, West Bengal, Maharashtra

### Disclaimer:

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