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Comparative Study of Performance Evaluation of Biomass based Rotary Tray Dryer and Solar Tunnel Dryer for Drying of Shatavari Roots (*Asparagus racemosus*)

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A B S T R A C T

The project entitled "Comparative study of performance evaluation of biomass based rotary tray dryer and solar tunnel dryer for drying of Shatavari" is carried out at Department of Unconventional Energy Source and Electrical Engineering, Dr. PDKV, Akola undertaken with the objectives to characterize agro residues based briquettes used for combustion in biomass based rotary tray dryer and evaluate performance of biomass based rotary tray dryer for drying of Shatavari in biomass based rotary tray dryer and solar tunnel dryer. The biomass heated air was supply to continuously to the drying chamber for drying of Shatavari roots. To the drying of Shatavari temperature ranges was used 45°, 55° and 65°C. The drying of Shatavri to the temperature in biomass heated air rotary tray dryer and solar tunnel drying result observed the inside drying chamber and combustor temperature were much higher than the ambient temperature during drying time. The drying process observed that drying time was minimized and organic content obtained more in biomass heated air rotary tray dryer was found better than solar tunnel drying. The quantitative analysis showed that the traditional drying i.e.., solar tunnel drying took 17h for drying of Shatavari roots to remove moisture content from 42.83% (db) to 9.37% (db), while biomass heated air rotary tray dryer took only 14 h for drying of Shatavari roots during 45°, 55° and 65°C required 12h moisture content was removed 8.33% (db) respectively.

Introduction

Asparagus racemosus (family Asparagaceae; Liliaceous), is commonly called Shatavari, Satawar or Satmuli in Hindi. The plant grows throughout the tropical and subtropical parts of India up to an altitude of 1500 m. The plant is a spinous under-shrub, with tuberous, short rootstock bearing numerous succulent tuberous roots (30–100 cm long and 1–2 cm thick) that are silvery white or ash colored externally and white internally. These roots are the part that finds use in various medicinal preparations. The root *Asparagus racemosus* (Shatavari) also has proved its effectiveness as a natural sex stimulant and spermaticgenie medicine in both male and female sexual and gynecological disorders. The root is important for increasing the seminal qualities due to its ability to increase sperm count as well as improves its motility enhances libido due to its general tonic effects. It also acts as a nutritive tonic.

Biomass is an organic matter of biological origin as a form of stored solar energy which, is captured by the organic matter as it grows.

Biomass is a renewable energy source and agriculture is its largest producer. For the agriculture sector, biomass will assume an increasingly important role as an energy source. Biomass is an important source of energy accounting for about one third of the total fuel used in India and in about 90% of the rural households.

Drying is a universal method of conditioning the grain to safe moisture content level. There are different sources of energy which can be integrated for drying purposes. However; solar drying offers a promising option in present energy quest for drying agricultural and industrial products.

The selection of the best type of dryer is not challenging task but that should not be taken lightly nor should it be let entirely to dryer vendors who typically specialize in only few types of dryer. The user must take a proactive role and employ vendors experience and bench scale or pilot scale facilities to obtain data, which can be assessed for a comparative evaluation of several options A wrong dryer for given application is still a poor dryer, regardless of how well it is designed. Open sun drying is slow and exposes the produce to various losses and deterioration in quality.

The main objectives includes to evaluate performance of biomass based rotary tray dryer. And also to evaluate performance of Solar tunnel dryer.

Materials and Methods

Biomass based rotary tray dryer

The biomass heated air rotary tray dryer tested in full load condition Shatavari roots dried at different temperature the selected temperature was below the 45$^{\circ}C$ one trial were taken at selected temperature 45, 55 and 65°C.

In full load test average drying chamber temperature, combustor temperature and relative humidity was obtained in trial (45°C). T1 (54.86°C), T2 (54), T3 (58.15°C), T4 (51.92°C), T5 (57.23°C), T6 (50.38°C), T7 (54.38°C), T8 (51.46°C) and outlet temperature (41.23°C) respectively. The average relative humidity of dryer was obtained during drying chamber RH1 (23.69%), RH2 (23.92%), RH3 (23.84%), RH4 (22.69%) and RH5 (24.07%) respectively.

The average drying chamber efficiency of the biomass heated rotary tray dryer was obtained in this temperature 45, 55 and 65°C.

The fuel rate was not fixed it feed by requirement of temperature and it feeding time also vary required fuel in trial 45, 55 and 65°C was 0.848 kg/hr, 1.329 kg/hr and 1.793 kg/hr.

Solar tunnel dryer

In this dryer the material used 65 kg of shatavari for drying 8 kg in each tray the total trays are 8.
It is the most commonly used method for drying in which air is circulated by force convection. The product is spread over the screened trays. The drying medium is air

which is heated generally in temperature range from ambient to 50°C during roots drying. The air velocity ranges from 0.1 to 1.9 m/s. combined and simultaneous heat and mass transfer operation for which energy must be supplied. The removal of moisture prevents the growth and reproduction of micro-organisms like bacteria, yeasts and moulds causing decay and minimizes many of the moisture-mediated deteriorative reactions.

Drying takes place due to the difference in moisture concentration between the drying air and the air in the vicinity of crop surface. The performance of the Solar Tunnel Dryers will evaluated for drying of Shatavari.

Open sun drying

The sun drying of Shatavari roots was done during the month Feb-March at 35-42°C temperature and 30% relative humidity. Solar drying is a continuous process where moisture content air and product temperature change simultaneously along with the two basic inputs of the system Le the solar insulations and the ambient temperature. The drying rate is affected by ambient climate conditions.

Results and Discussion

Determination of moisture content

The initial moisture content of sample was determined by the hot air oven drying method. The samples were placed in hot air oven at 105 ± 0.5^0 C for 24.00 h. following formulae were used (Chakraverty, 1988).

$$\text{M.C.(wb)\%} = \frac{(W_1 - W_2)}{W_1} \times 100$$

$$\text{M.C.(db)\%} = \frac{(W_1 - W_2)}{W_2} \times 100$$

Where,

W_1= Weight of sample before drying, g

W_2= Weight of bone dried sample, g

Determination of moisture ratio

The Moisture ratio of the produce will be computed by following formula (Chakraverty, 1988).

$$\text{Moisture Ratio (M.R.)} = \frac{(M - M_e)}{(M_0 - M_e)}$$

Where,

M = Moisture content (db) in %

M_e = EMC, (db) in %

M_0 = IMC, (db) in %

Determination of drying rate

The drying rate of produce sample during drying period will be determined as follows: (Chakraverty, 1988).

$$\text{Drying rate } (D_R) = \frac{\Delta W}{\Delta t}$$

Where,

ΔW = Weight loss in one h interval (gm/100gm b/dm min.)

ΔT = Difference in time reading (h)
In full load test the Shatavari roots was poured in the perforated iron tray in thin layer. The experiment was conducted on threshed Shatavari roots. The initial weight of the samples was recorded. The samples were

weighed regularly at an interval of 2.00 h and simultaneously the temperature, relative humidity was noted. The drying was conducted between 9.00 to 17.00 h daily up till it reaches to equilibrium moisture.

Full load testing of Solar Tunnel Dryer

In full load test the roots of Shatavari will spread over the perforated aluminum tray in thin layer. The experiment will be conducted after harvesting of Shatavari. The initial weight of the samples will be recorded.

The samples will be weighed regularly at an interval of 2.00 h and simultaneously the temperature, relative humidity, solar radiation and wind velocity will be recorded. The drying will be conducted between 9.00 to 17.00 h daily.

Variations in temperature during the drying of Shatavari in solar tunnel dryer

The data presented showed that the initial moisture content and representing reduction in moisture content after 2 hrs interval in solar tunnel dryer and fig 4.18 showed that the ambient temperature and solar radiations with respect to drying time. It showed that initial temperature just after starting of drier was 29.3°C corresponding to the ambient temperature 33.3°C. The minimum and maximum temperatures inside the solar tunnel dryer were 39.2°C and 60.2°C respectively corresponding temperature of 60°C respectively. The outlet temperature was 33.8°C.

Variation in weight loss of Shatavari roots in biomass based rotary tray dryer

The data showed that the moisture content of Shatavari roots decrease of 2 hrs interval in the biomass based rotary tray dryer, ambient temperature and relative humidity with respect to drying time. It showed that initial moisture content of each tray just after starting of drier was 20˚C corresponding to the ambient temperature 23˚C. The minimum and maximum temperatures inside the biomass based rotary tray dryer were 54˚C and 69˚C respectively corresponding to the constant feeding temperature of 65˚C at 2800 rpm.

The data presented in Fig.1 showed that the ambient temperature and relative humidity during full load test. It showed that minimum ambient temperature was 25˚C at 9:30 h. Maximum ambient temperature attained was 44°C at 14:30 h with corresponding ambient relative humidity of 13% respectively

The data presented in Fig 2 showed that the relative humidity with respect to drying time. It showed that initial temperature just after starting of drier was 27˚C corresponding to the ambient temperature 33˚C. The minimum and maximum temperatures inside the biomass based rotary tray dryer were 45˚C and 55˚C respectively corresponding to the constant feeding temperature of 45°C at 2800 rpm respectively. The outlet temperature was 36℃. The relative humidity inside the biomass rotary drier was found to be 22% corresponding to ambient relative humidity 29% respectively.

Table.1 Variations in temperature during the drying of Shatavari in solar tunnel dryer

Sr. No	Time. (hr)	Temp. Front side in the dryer	Temp. at middle in the dryer	Temp. at end side in the dryer	Tem. Upper tray	Temp. middle tray	Temp lower tray	Amb.Temp. (°C)	Solar radiation (W/m^2)
1.	09:00	35.9	39.6	39.2	43.0	39.6	41.2	29.3	**200**
2.	11:00	51.7	46.2	55.5	61.0	54.0	52.6	35.7	**570**
3.	14:00	54.9	60.2	57.8	65.2	57.8	56.1	37.4	**420**
4.	15:00	47.2	50.6	49.6	51.3	51.3	51.4	35.9	**380**
5.	**17:00**	**40.1**	**43.1**	**42.8**	**41.9**	**42.0**	**43.7**	**33.3**	**250**

Table.2 Variation in weight loss of Shatavari roots in biomass based rotary tray dryer

No. of Trays. Day-1	Wt. of tray without sample in (Kg)	Wt. of sample in (Kg)	Total wt of sample in tray(Kg)	After 1hr.	After 2hr.	After 3hr.	After 4hr.
1.	6.251	8.098	14.349	14.170	14.053	13.896	**13.776**
2.	6.243	8.804	15.047	14.823	14.690	14.514	**14.399**
3.	5.487	8.302	13.789	13.569	13.437	13.255	**13.130**
4.	6.537	8.580	15.117	14.879	14.798	14.567	**14.437**
5.	5.375	7.895	13.270	13.014	12.876	12.685	**12.572**
6.	6.213	7.499	13.712	13.576	13.492	13.370	**13.256**
7.	6.213	7.948	14.161	14.046	13.970	13.848	**13.708**
8.	**6.369**	**7.965**	**14.334**	**14.199**	**14.112**	**13.978**	**13.818**

Table.3

Temp. at Position	Initial	After 1 h	After 2 h	After 3 h	After 4 h	After 5 h	After 6 h	After 7 h	After 8 h
Bin T1	22	48	48	47	47	47	47	46	48
Bin T2	21	49	49	48	48	48	48	47	55
Bin T3	25	55	55	54	54	44	44	55	47
Bin T4	18	48	48	47	47	47	47	46	53
Bin T5	24	54	54	52	52	53	53	54	42
Bin T6	19	45	43	42	41	41	41	43	50
Bin T7	21	50	50	49	49	50	50	51	46
Bin T8	17	47	47	46	46	47	47	57	47
Bin Outlet T9	26.2	36.4	36	35.8	43.9	33.9	33.9	37.2	35.5
CHT 1	35	37	37	38	36	36	36	37	37
CHT 2	29	42	41	42	39	39	39	45	39
CHT 3	37	45	45	44	42	41	41	43	43
CHT 4	29	48	46	46	43	42	42	54	45
CHT 6	28	49	50	47	44	45	45	54	47
CHT 7	31	52	36	51	48	49	49	58	38

Fig.1

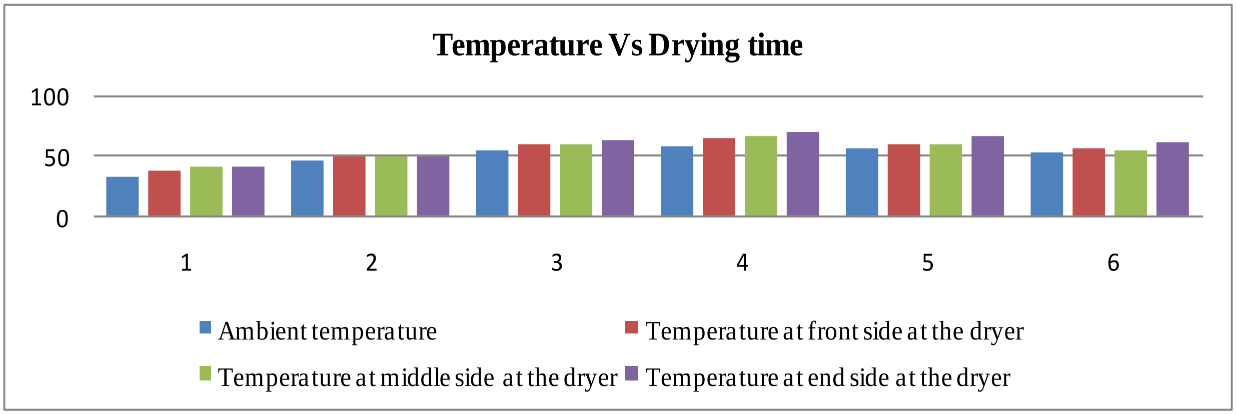


Fig.2 Variation in temperature and relative humidity during full load test in open sun drying of Shatavari roots.

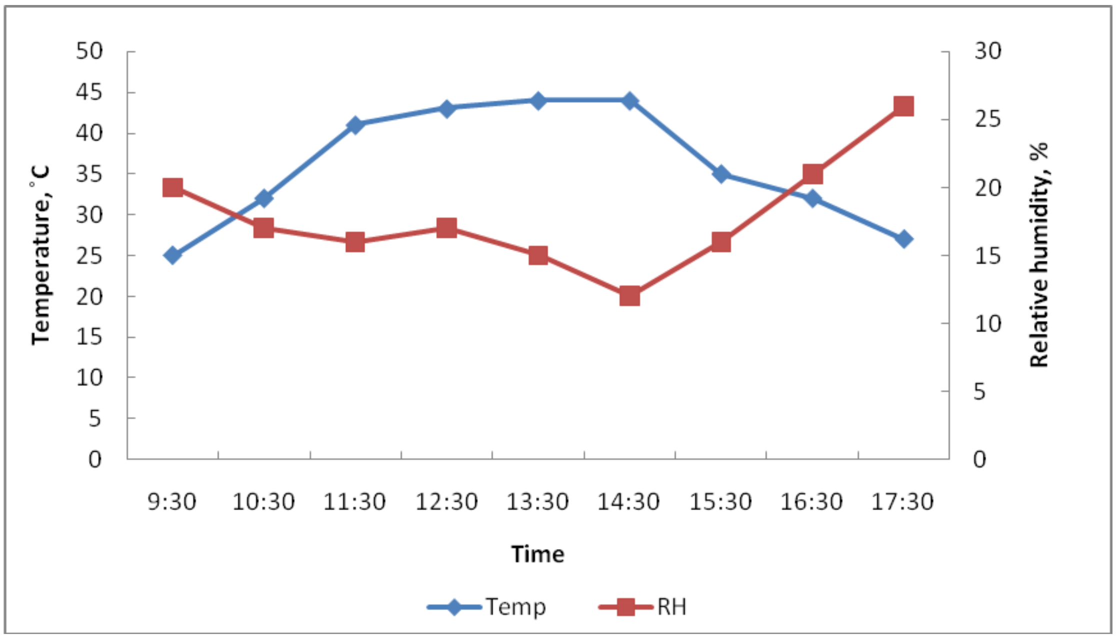


Fig.3 Variation in relative humidity during full load test in biomass based rotary tray dryer with respect to drying time (At 45˚C & 2800 rpm)

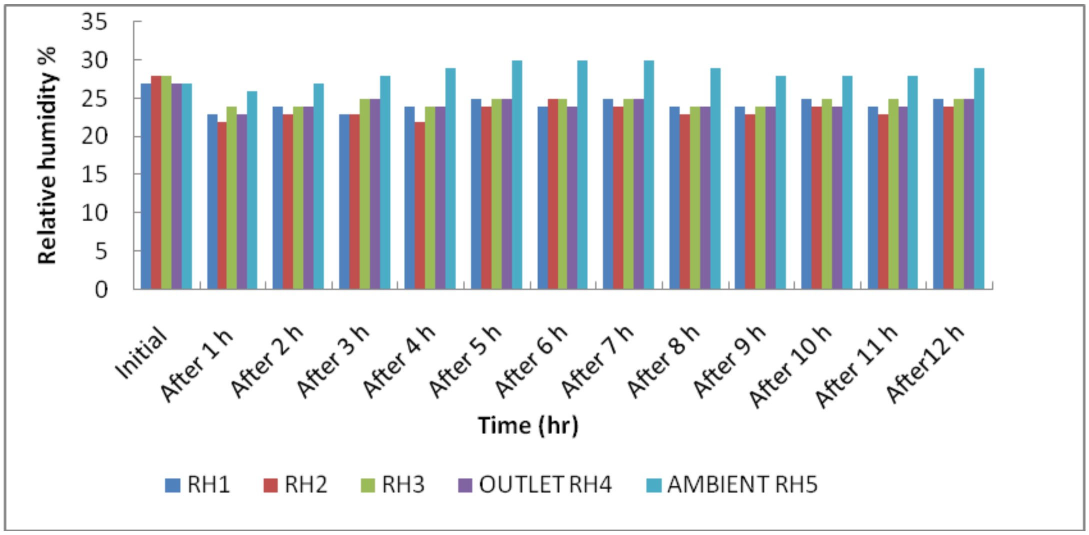


Fig.4 Variation in temperature during full load test in biomass based rotary tray dryer with respect to drying time (At 55˚C & 2800 rpm)

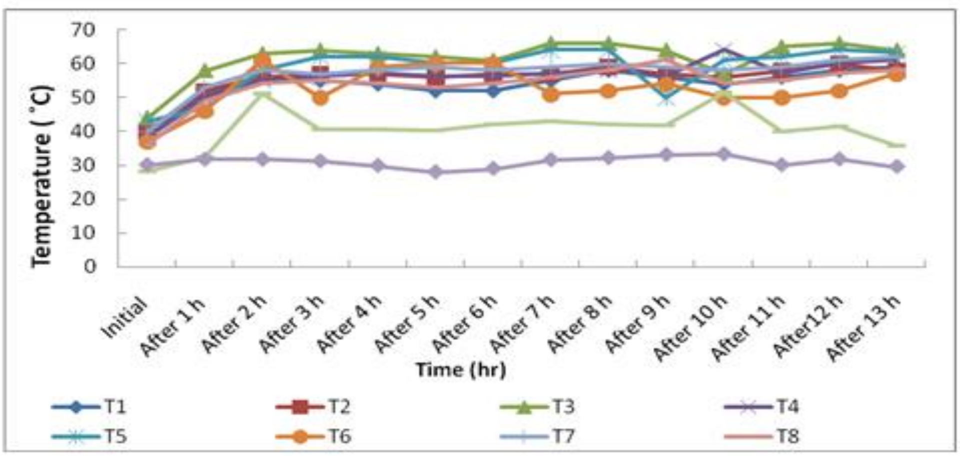


Fig.5 Variation in relative humidity during full load test in biomass based rotary tray dryer with respect to drying time (At 55˚C & 2800 rpm)

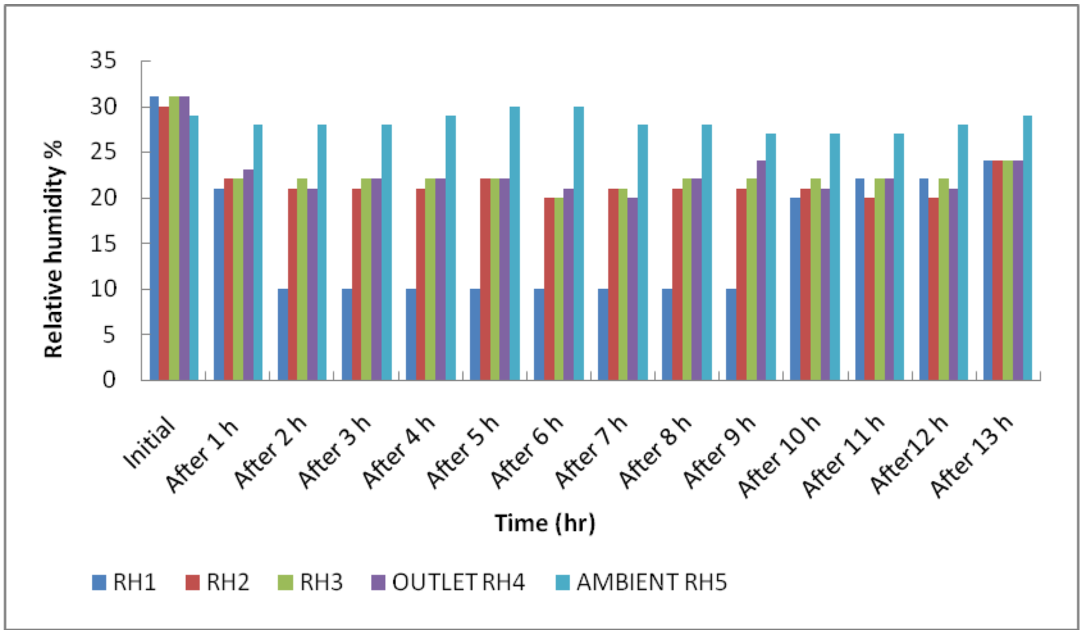
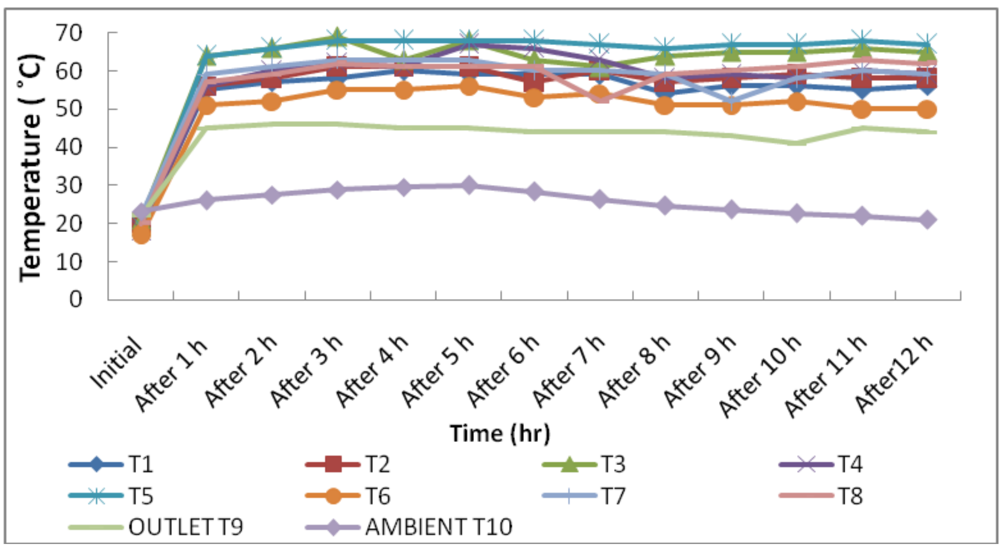


Fig.6



The data presented in Fig.3 showed that the temperature inside the, ambient temperature with respect to drying time. It showed that initial temperature just after starting of drier was 30℃ corresponding to the ambient temperature 40℃. The minimum and maximum temperatures inside the biomass based rotary tray dryer were 45℃ and 55℃ respectively corresponding to the constant feeding temperature of 55℃ at 2800 rpm respectively. The outlet temperature was 36℃. The relative humidity inside the biomass rotary drier was found to be 25% corresponding to ambient relative humidity 20% respectively. The data presented in Fig 4 showed that the temperature inside the biomass based rotary tray dryer, ambient temperature and relative humidity with respect to drying time. It showed that initial temperature just after starting of drier was 40℃ corresponding to the ambient temperature 31℃. The minimum and maximum temperatures inside the biomass based rotary tray dryer were 53℃ and 62℃ respectively corresponding to the constant feeding temperature of 55℃ at 2800 rpm respectively. The outlet temperature was 42℃. The relative humidity inside the biomass rotary drier was found to be 20% corresponding to ambient relative humidity 29% respectively.

Biomass based rotary tray dryer –Drying time for Shatavari in this dryer require less 5.2% time as compared to solar tunnel dryer & open sun dryer, but the dryer require more electricity, manpower, operating cost is more 258 Rs/kg shatavari as compared to solar tunnel dryer.

Solar tunnel dryer

In this dryer does not require electricity, hence electricity cost reduced it require only 1 manpower as compared to biomass based rotary tray dryer, hence overall operating cost is less 195 Rs/kg Shatavari, but drying time for Shatavari is more 7.8% as compared to biomass based rotary tray dryer but it is safe for operation as well.

Open sun dryer

Open sun drying needs more 9.75% time for drying of Shatavari it does not require electricity and manpower, but there may not be any control and quality of product during drying. Shatavari color are totally different, foreign particles, dust may after on product drying. Hence, by considering above points drying of Shatavari in solar tunnel dryer is economical, safe and better.

Therefore, 1 kg of Shatavari for drying in biomass based rotary tray dryer require 258 Rs/kg and in solar tunnel dryer 1 kg of Shatavari require 195 Rs/kg.

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