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Drying of Red Chilli in Photovoltaic Powered Greenhouse Dryer

Samreen[1], M. Madhava[2] and A. Rama Rao[3]

1.Ph.D Scholar, Dept. of Process & Food Engg., College of Agricultural Engineering, Bapatla, Andhra Pradesh

2. Asst. Professor, Dept. of Process & Food Engg., College of Agrricultural Engineering, Bapatla, Andhra Pradesh. 3. Ph.D graduate, College of Agricultural Engineering, Bapatla, Andhra Pradesh

ABSTRACT

A forced ventilated solar green house dryer was developed for carrying out the experimental and comparison studies of drying characteristics of red chillies during the month of April, 2016 in Bapatla, region of Guntur, Andhra Pradesh, India. About 50 kg of red chillies were loaded into the dryer. The drying parameters such as drying time, moisture content were studied in PV ventilated solar greenhouse dryer and in open sun drying. The red chillies which has an initial moisture content of 63.8% (w.b.) was reduced to a final moisture content of 8.01% (w.b.) over a time period of 5 days in the forced ventilated solar green house dryer. The open sun drying method took 8 days for reducing the moisture content of red chillies to the same level. The quality of red chillies produced from the solar tunnel greenhouse dryer was found to be superior to open sun drying method.

Keywords: Drying time, moisture content, open sun drying, forced ventilation, green house dryer.

Introduction

Chilli (*capsicum annuum linn*) is also called as hot pepper. Chilli is considered as one of the most important commercial spice crops and is widely used universal spice. Chilli occupies an important place in Indian diet. Currently, chillies are used throughout the world as a spice and also in the making of beverages and medicines. Chilli is rich in vitamins, especially in vitamin A and C.

Andhra Pradesh has a production of 5.58 lakh MT from 1.74 lakh hectares of area, which accounts for 26 % percent of area and 54 % percent of production in the country. In Andhra Pradesh it is grown in all the districts namely Guntur, Prakasham and some other districts. The production of chilli in India is dominated by Andhra Pradesh which contributes nearly 54%. Karnataka is second largest contributing 12%. Guntur is the biggest chilli production region contributing 30% to the production of Andhra Pradesh and is being exported to USA, UK, Japan, France, Sri Lanka etc. to a tune of Rs.100 crores annually.

Chillies, which contain high moisture content (300-400% d.b.) after harvest, are highly perishable and hence processing and storage of chillies are of considerable important both to the farmers as well as to the processor and consumer. The shelf life of freshly harvested chillies is estimated to be 2-3 days based on 12-15% cumulative loss. It is essential to reduce the moisture content and provide aeration to the chillies after harvesting to avoid development of microflora and subsequent loss of quality or total spoilage. Therefore, chillies need to be dried quickly without impairing colour and pungency.

Traditionally, fresh chillies are preserved by drying the fruits immediately after harvest under the sun without any special treatment. In traditional drying, the fruits are spread out in the sun on hard dry ground/concrete floor/flat roof of house by spreading chillies in thin layers. The chillies are turned frequently so that drying is uniform and there is no discoloration or mould growth. Sun drying of chillies takes 14-21 days depending on weather. Natural Circulation Solar Cabinet dryer are basically used for drying low quantity of chillies. The dryer consists of a container, insulated at both its base and sides and covered with a double-layered transparent roof. Drying temperatures in excess of about 80 ºC were reported for the dryer (Biplab Paul,2013).

A solar greenhouse has thermal mass to collect and store solar heat energy, and insulation to retain this heat for use during the night and on cloudy days. A solar greenhouse reduces the need for fossil fuels for heating. Solar drying of agricultural products in enclosed structures by forced convection is an attractive way of reducing post-harvest losses and low quality of dried products associated with traditional open sun-drying methods. In many rural locations in most developing countries, grid-connected electricity and supplies of other non-renewable sources of energy are unavailable, unreliable or, too expensive. In such conditions, solar dryers appear increasingly to be attractive as commercial propositions.

Active solar greenhouses use supplemental energy to move solar heated air or water from storage or collection areas to other regions of the greenhouse. The PV applications of solar energy can provide electricity, thermal energy, day lighting etc. Solar electric, or photovoltaic (PV), systems convert sun light directly to electricity. In areas with no utility lines, PV systems are often cheaper and require less maintenance than diesel generators, wind turbines, or batteries alone. PV module produces electricity, which can be used to operate DC fan for removal of humid air from greenhouse. PV integrated greenhouse dryer may be one of the most suitable and alternative choice in remote areas to dry paddy using solar energy where the grid electricity is not available.

Materials and Methods

Freshly harvested red chillies of local variety (Guntur sannam-S4) were obtained from the local market. The moisture content of fresh chillies was around 68.3% w.b. and it was dried up to 8% w.b. for safe storage.

Forced ventilated greenhouse dryer was constructed in the premises of College of Agricultural Engineering, Bapatla, Andhra Pradesh, India which is located at 15.8889° N, 80.4700° E and elevation 7 m from MSL. The site selected has levelled surface, well aerated, fairly shadow free to enable to receive good solar radiation. As per as sunlight availability is concerned, in case of free standing greenhouse, there is more sunlight available in winter in east-west oriented greenhouse in comparison to north- south one(Tiwari, and Goyal, 1998). Hence east-west orientation was selected for greenhouse structure. Forced ventilation greenhouse dryer has 14 feet length and 7 feet width and 8.5 feet (2591mm) height size. Arch roof design was used as shown in Fig. 1. Greenhouse dryer has the provision to accommodate 18 trays in two rows and three tiers. There is sufficient space between the two rows of the trays helps in monitoring and intermittent mixing the product. Multi wall ultraviolet resistant, 6mm thick polycarbonate sheet used to cover the greenhouse structure. Poly carbonate sheet was fixed to the frame with the help of Aluminium profile and self tapping screws. The trays were used for holding the chillies inside the drying chamber of the greenhouse dryer. The trays are fabricated with mild steel angle and mild steel flat material. Each tray is having 142.5 cm length, 80 cm width and 15 cm height. No.11 size wire mesh having specifications of 0.8 mm diameter, 2.83 mm aperture, open area 61% and weight 2.24 kg/m^2 was used cover the tray frame.

Fig. 1 Forced ventilated solar green house dryer

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The two no 150 watt power capacity solar photovoltaic panels with 18.5V rated voltage and 8.10A rated current was used to drive the DC Exhaust fans. Solar panels were always tilted and oriented in such a way that it receives maximum solar radiation during the desired season of use. Chilies were dried at two bed thicknesses, one was 2.5 cm depth and the other was 5 cm depth both in open sun drying and forced ventilated solar green house dryer as shown in Fig.2.

Fig. 2. Different bed thickness in open sun drying and forced ventilated solar green house dryer.

A pyranometer was used for measuring total solar radiation, the sum of beam and diffuse radiation. Global radiation was measured with an Apogee SP 110 pyranometer. Lutran 4201 anemometer was used to measure the wind speed for hourly during the experiment. A data logger is an electronic instrument used for recording measurements at set intervals over a period of time. Process precision Instruments (PPI), India data logger was used to record the readings at 1 minute interval.

The moisture ratio (MR) can be calculated by the following formula (Arun, 2014).

$$MR = \frac{M - M_e}{M_i - M_e}$$

Where M: the moisture content at any time t, M_e: equilibrium moisture content and M_i: initial moisture content with all expresses in dry basis.

The drying rate (DR) is expressed as the amount of evaporated moisture overtime (Ahmad, 2013).

$$DR = \frac{M_{t+dtt} - M_t}{dt}$$

Where: moisture content at time t and M_{t+dt}: moisture content at time $t + dt$

A master thermometer was used to calibrate the thermometers in this experiment and the temperature range is 20 to 80 °C. The tolerance of T-type thermocouple is 0.5°C.

Results and Discussions

The solar radiation varied in the range of 355.45 W/m^2- 931.25W/m^2. The maximum solar radiation observed was about 931.25 W/m^2 as shown in Fig. 3. The solar radiation was minimum in morning, increased to reach maximum at 1.00 PM, later it followed decreasing trend till the evening. It was also observed that with the increase of light intensity variation of ambient temperature and green house temperature were stated. It was observed that all the 8 hours of the day suitable for drying in open sun and solar dryer.

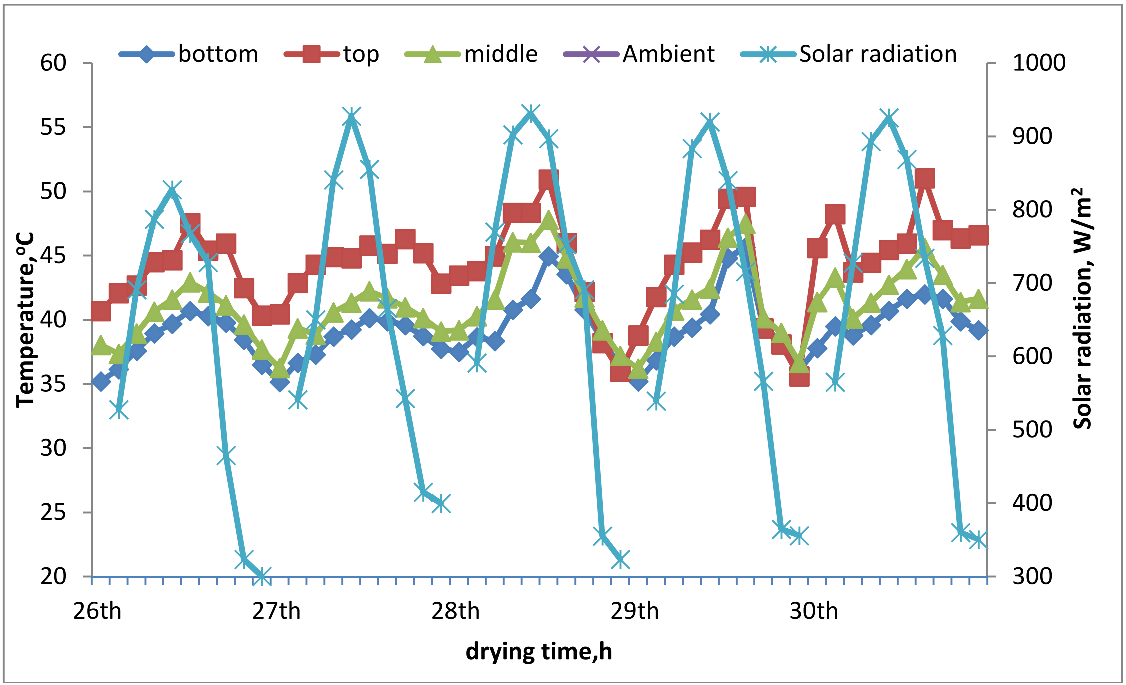

Figure 3. Variation of different temperatures and solar radiation with drying time.

During the experimentation the relative humidity of dryer varied from 30% to 58% where has relative humidity inside the green house dryer varies from 22% to 41%. The relative humidity of air at top trays is lower than middle and bottom trays in the dryer as shown in the Fig. 4. The relative humidity also follows trend of first decreasing and then increasing. In all the days of the experimental period, the relative humidity of the dryer was found to be less than that of ambient relative humidity due to the high temperature prevailing inside the dryer (due to the green house effect).

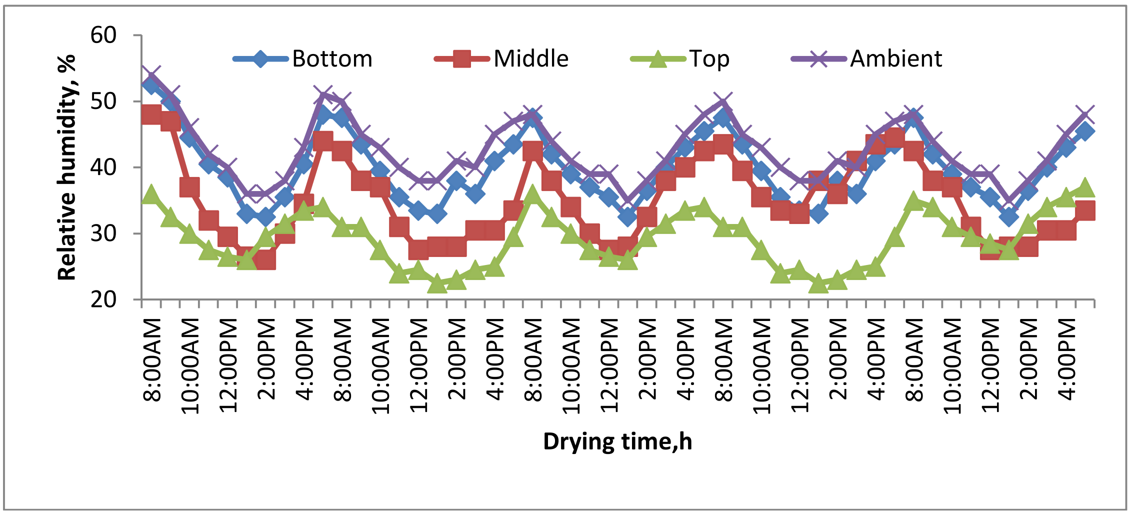

Fig. 4.Variation of relative humidity with drying time

During the experiment, the chillies were placed in two different bed thickness 2.5 cm and 5 cm. While comparing the moisture content of chillies arranged in 2.5 cm bed thicness, the moisture content of the red chillies inside the dryer reduced from 63.8 to 8.01% in 5 days whereas for the red chillies dried in open sun drying method, it is reduced from 63.8 to 8.21%, 8 days where has moisture content of chillies arranged in 5 cm depth reduces from 63.8 to 10.4% in the dryer and in the open sun drying moisture content reduces from 63.8 to 10.2%. In the duration of 5 days the chillies losses its moisture from 63.8% to 8.01% (2.5 cm depth) and from 63.8 to 10.4% (5 cm depth) in the dryer where as in open sun drying it takes 8 days to obtain the

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8.21% (2.5 cm depth) and 10.2% (5 cm depth) of moisture. It is evident from the Fig.4 that the poly house dryer dried the red chillies at an earlier time than the open sun drying method which is basically due to the high temperature and low relative humidity prevailed inside the dryer as a result of greenhouse effect. Also, in the poly house dryer there would not be any degradation in quality of red chillies that can be caused by contamination, damage by birds and animals, windborne problems like dust & dirt and infections by fungus and bacteria which were seen predominantly in the open sun dried red chillies.

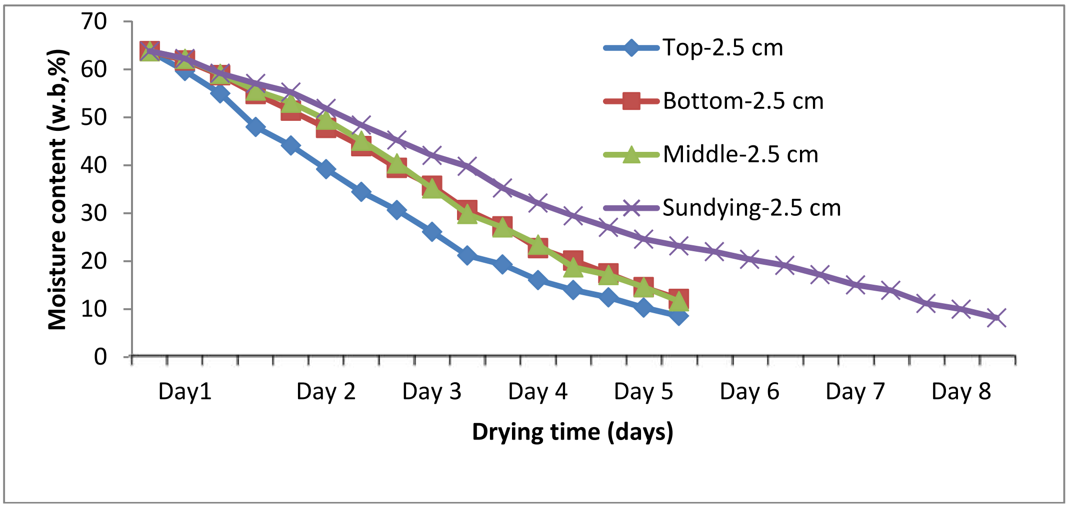

Fig. 4.Variation of moisture content of bed thickness 2.5 cm with drying time

Thickness of bed also plays a major role effecting the drying time and capacity of the dryer, if the dryer loaded with 2.5 cm bed thickness the capacity of dryer would be 3.0 Kg but takes less time for drying. If the dryer loaded with 5 cm bed thickness the capacity will be more that is 4.0 Kg, but the drying time will be increased slightly. As we taken two different thickness of bed the chillies with 2.5 cm bed thickness dries faster than chillies with 5 cm bed thickness. The porosity of 2.5 cm bed is higher than 5 cm bed so that the moisture content losses more faster in the bed with more porosity as shown in the Fig. 5.

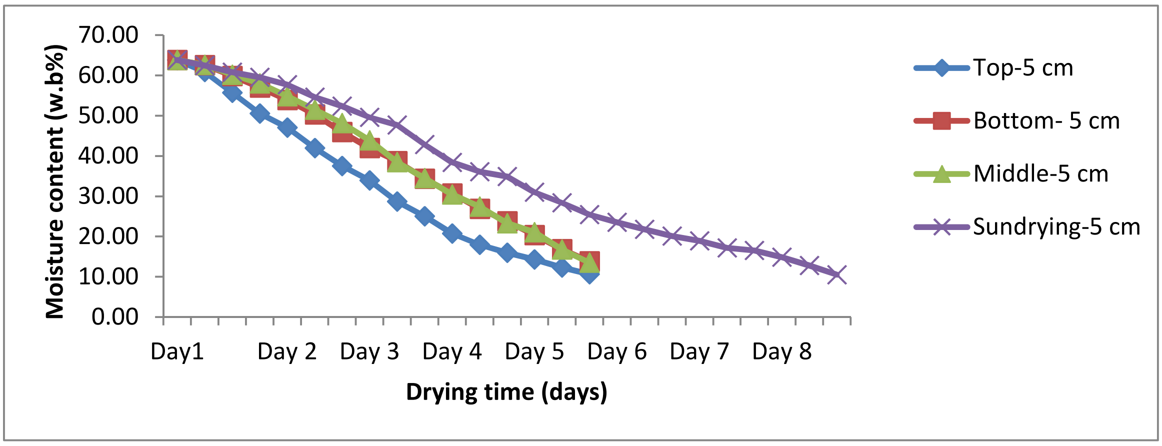

Fig.5. Variation of moisture content of bed thickness 5 cm with drying time

Drying rate is major parameter to determine drying characteristics of red chillies. As shown in the Fig. 6 the drying rate of top trays in dryer ranges from 10.361 to 3.723 Kg water/Kg dry solid-h. For middle trays it ranges from 6.486463 to 3.72143 Kg water/Kg dry solid-h. For bottom trays the range of drying rate is 4.400932 to 2.750472 Kg water/Kg dry solid-h. For sun drying the drying rate ranges from 5.170808 to 2.323594 Kg water/Kg dry solid-h. The drying rate of top, middle, bottom and sun drying first increases and the trend decreases as the drying time increases. For sun drying, drying rate follows the trend of increasing and then it slightly decreases.

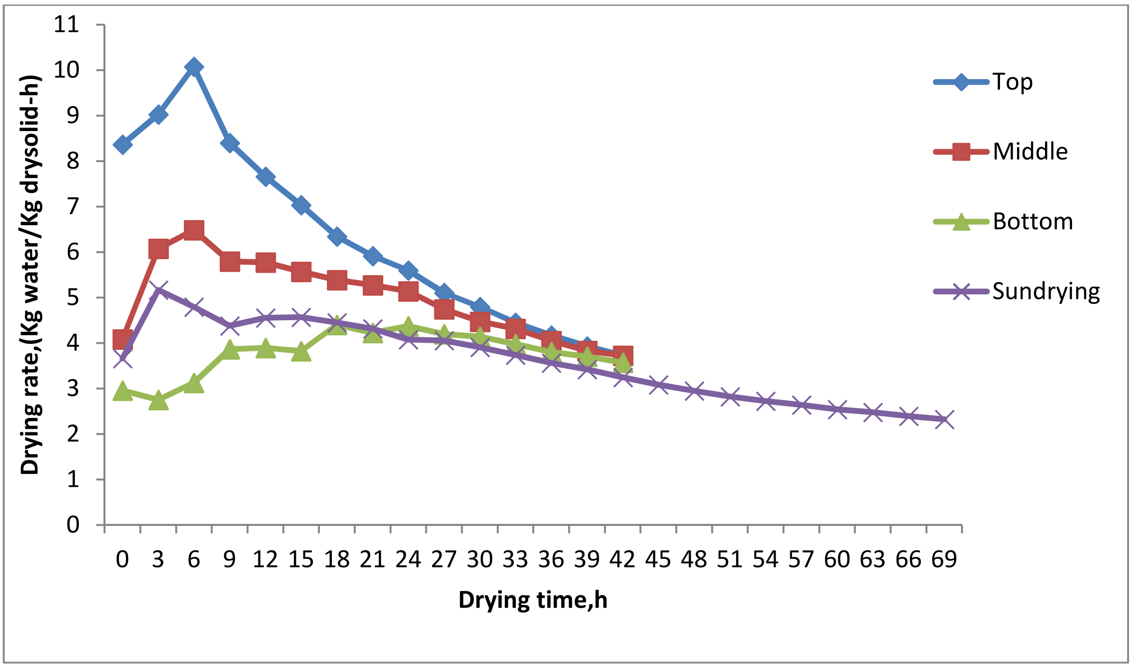

Fig. 6. Variation of drying rates with drying time

The airflow rate changes as the velocity of air changes. The maximum airflow rate calculated is 99.43 m^3/min and minimum is 35.9 m^3/min. As the airflow rate increases the removal of relative humidity from the dryer also increases.

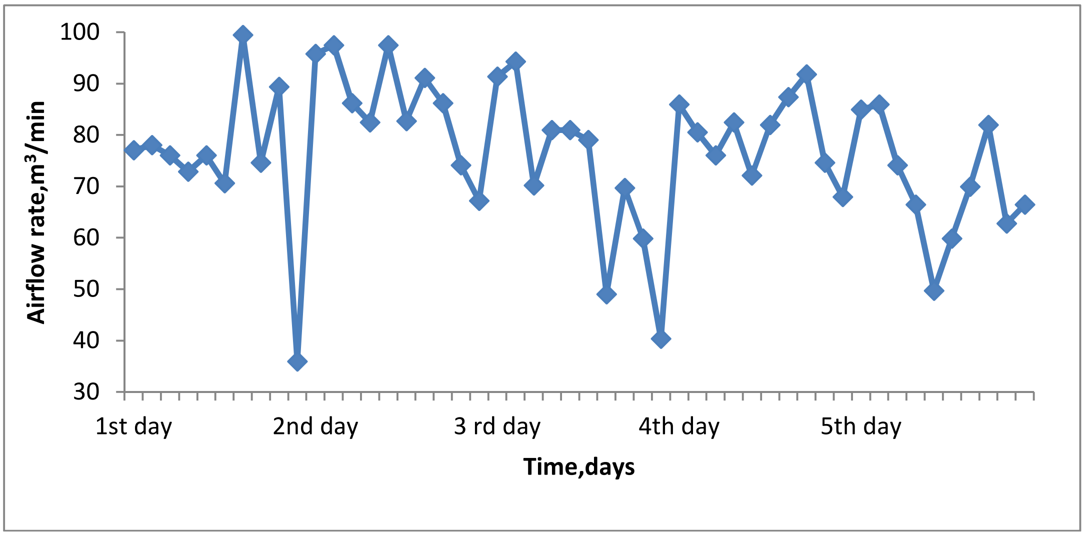

Fig. 7. Variation of Air flow rate and solar radiation with time

Conclusions

It was observed that during the drying process the moisture content of the red chilies decreases. It was found that during the drying the temperature inside the forced ventilation greenhouse dryer is higher than the temperature outside. The solar radiation varied in the range of 355.45 W/m^2- 931.25W/m^2. The relative humidity of dryer varied from 30% to 58% whereas relative humidity inside the greenhouse dryer varies from 22% to 41%. It was concluded that the drying of red chillies in solar tunnel green house dryer was faster than drying in open sun drying.

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