IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 70-73
www.iosrjournals.org

Design and Performance Evaluation of Solar dryer

P. K. Wankhade[1], Dr. R.S.Sapkal[2], Dr. V.S.Sapkal[3]
Chemical Technology Department, S. G. B. Amravati University.

ABSTRACT: *Drying is an essential process in the preservation of agricultural products. Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Drying of foods, the key is to remove moisture as quickly as possible at a temperature that does not seriously affect the flavor, texture and color of the food. Various drying methods are employed to dry different agricultural products. In present work local made solar dryer is used which is modified in form of vents for natural air flow in dryer and also platform constructed, which is made up of galvanized wire mesh which allow the free flow of air around the product by natural circulation. Fan/blower is used for forced circulation and to increase the air velocity. And experimentation was carried out in both cases on some agricultural product to study the effects on performance in different parameters after drying in the month of march and april. The results also revealed the dependence of the dryer performance on the proper air circulation through the system. The dryer efficiency increased as the air velocity through the system increased.*

Keywords: *Food Preservation, Drying methods, Solar dryer, Performance evaluation, Drying efficiency.*

I. INTRODUCTION

Drying is the reduction of moisture from the products and is a most important process for preserving agricultural products since it has a great effect on the quality of the dried products. The major objective in drying agricultural products is the reduction of the moisture content to a level which allows safe storage over an extended period. In addition, drying enhances the storability, transportability, nutritional value retention, flavor and texture of food products. It is used for the preservation of a wide variety of agricultural products. However, the ever-rising cost of electricity and natural fuels in addition with growing concern about their availability in both the short and long terms, has resulted in growing interest in the use of renewable resources especially solar energy. Drying of agricultural products such as corn, rice, millet, beans, sorghum, groundnut, pepper, okra, potato, and yam chips requires a considerable amount of energy, which must be available when the crop is harvested. The application of solar energy in drying of agricultural products has tremendous potential, since it can easily provide the low temperature heating required for drying. Drying processes using solar energy range from traditional open sun drying to solar dryers. The climatic conditions during harvest season in some areas may be such that unheated or natural air can be used to reduce the moisture content in the crop to safe storage moisture.

However, in the natural air drying technique has the problems of contamination, infestation, microbial attack, and the required drying time for a given commodity can be quite long. Where feasible, solar drying often provides the most cost-effective drying technique which provide air with greater drying potential which in turn flows by natural or forced convection through a bed of the product to be dried. Since the material is contained there is less contamination and it is less susceptible to adverse weather conditions (Akbulut and Durmus, 2010). Solar energy in is available for 8 to 9 months in a year with average sunshine hours ranged from 6.5 to 8 hours per day. The average solar energy ranged between 450-500 cal/cm² in a day. At present the fruits are used for drying due to their availability and good market value at local level. It is a fruit dried and used as sour agent in cookery. The only alternative available is drying (Senadeera et al.,2003), which is most important techniques of food preservation (Menon and Muzumdar, 1987). To reduce the processing losses during the drying and to retain the quality of dried product, it is necessary to dry such fruit in the close chamber(Lambert, 1980) with preventing product from dust, insect, larva, birds and animal (Ong, 1999). By keeping importance of drying, low cost solar dryer was fabricated to carry out solar drying study.

II. MATERIALS AND METHODS

Dryer setup:

In all the views, it can be deduced that to achieve better drying rates, a proper circulation of heated air through the dryer is required. In the developing countries, the agricultural practice of drying is mostly undertaken in the rural areas where electricity does not exist to power the fan. In this study a vents for natural circulation was incorporated into the dryer, to increase the rate of air circulation through the dryer. Also presented in this work is the detailed explanation of the design, construction and performance evaluation of the solar dryer. The experimental set up used for determining the influence of various drying methods on the drying behavior of agricultural product. The laboratory scale batch type hot air dryer is used and solar dryer used in present which is modified in form of vents for natural air flow in dryer and also platform constructed as in FIG.1. It is made up of galvanized sheet of 28 gauge size. Glass of 3mm thickness is placed at about 30° inclined. Area of surface area of drying platform is about 0.6 m2, which is made up of galvanized wire mesh. And its inner surface is coated with black colour. Vents are provided for natural air flow in dryer.

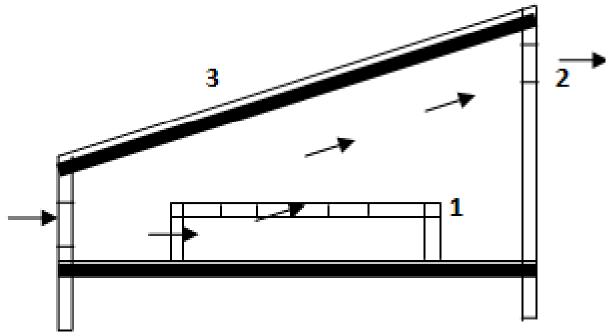

FIG1: Schematic Diagram of Solar Dryer

1. Wire mesh platform, 2.Vent for air flow
3. Glass cover

Measurements:

The temperature and humidity at different location inside the drying chamber and outside environment was measured with thermocouple. In order to measure reading at a different point of air column through top and bottom of drying bed, temperature sensor were set at inlet and outlet as well as mid position of drying chamber. Airflow rate along the drying chamber was calculated by measuring the velocity of exist air opening through an anemometer.

Moisture Content:

The percentage moisture content was determined by using following formula,

$$Mc = \frac{Mi - Md}{Mi} x\ 100\%$$

Where, *Mi* is the mass of sample before drying and *Md* is the mass of sample after drying.

Drying Rate:

The drying rate of sample during drying period was determined as follows,

$$Rd = \frac{Mi - Md}{t}$$

Where, *t* is time interval of drying readings

Moisture Ratio:

The Moisture ratio of prawns was computed by using the initial moisture content (IMC) and equilibrium moisture content (EMC)

$$M\mathrm{R} = \frac{M - Me}{Mo - Me}$$

where, *MR* is the dimensionless moisture ratio, *M*, *Me* and *Mo* are the moisture content at any time, the equilibrium moisture content and the initial moisture content in kg respectively.

Drying Efficiency:

Amount of heat required to evaporate the moisture inside the product is called as drying efficiency. Total heat in case of solar dryer is the availability of solar radiation on collector surface of the dryer. This drying efficiency was calculated by equation,

$$\boldsymbol{\eta}d = \frac{W\ x \bigtriangleup Hl}{Ac\ x\ Ic}$$

Where, *W*= moisture evaporated (kg), $\bigtriangleup Hl$ = Latent heat of vaporization of water, 2320 (kJ/kg), *Ic*= Total hourly isolation upon collector, (Wm²), *Ac*= Area of collector (m²)

Sample Analysis:

The sample slices were then weighed exactly 100 gms. for each treatment. These were kept for drying in three replications. For solar drying the weighed okra and potato slices were taken in paper plates and kept inside the solar dryer platform. Observations on physiological loss in weight and colour change in each sample were recorded at the particular interval of 1 hour in solar drying. The change in color of slices was observed for further analysis. The texture of end produce was also tested by breaking the dried slices and the produce was categorized into different grades. Temperature and relative humidity in solar drying was recorded throughout the drying period using hygrothermometer.

The solar drying experiments were carried out during the periods of March-April under the clean climatic conditions of vidarbha. Each experiment started at 8:00 am and continued till 18:00 pm. To determine the moisture loss of drying samples during experiments, samples were taken out of the solar dryer and weighed at various time intervals, ranging from 30 min at the beginning of the drying to 1hr during the last stage of the process during natural circulation. The moisture loss of samples was determined with the help of a digital electronic balance having an accuracy of 0.01 g. Same process is carried out by introducing blower at the vent opening of solar dryer, which supplies continues air about 1-1.5 m/s through solar dryer around the sample platform in form of forced circulation. And weighed at the same interval. These were again spread in the dryer in the next morning and the drying process was continued until no further changes in their mass were observed.

III. RESULT AND DISCUSSION

In the no load condition of solar drying, radiation and temperature inside the cabinet were measured with time of day in the interval of 30 minute were plotted in Figure 2. Maximum temperature observed at at 14.15 pm was 57°C ,whereas maximum ambient temperature observed was 37.2°C. Initial moisture content of okra slices was found to be 85 percent and 76 percent in potato slices. These samples were dried up to 10 percent moisture content inside the solar dryer. Time required to each condition for sample drying was calculated. The effect of different drying conditions on drying time, color and texture of the okra slices were determined. The result shown that there was a general decline in moisture content of the sample from 100 g to 15 g in all methods of drying.

The results analyzing to drying of sample are recorded in different conditions natural circulation solar drying and forced circulation solar drying are shown in fig. 3. The data indicated that the loss of moisture was at its highest magnitude in the first hour of drying however the moisture loss was slowed down in the subsequent drying period. The hourly variation of the temperatures in air and the drying cabinet compared to the ambient temperature for the day of drying are shown in Fig. 2. The hourly variation of the incident solar radiation shows the effect of air velocity on the drying efficiency. The system drying efficiency increases as the air velocity increases. This clearly reveals the dependence of the dryer performance on the air velocity shown in Fig. 3. The average air velocity through the solar dryer during the period of test at forced circulation was 1.5 m/s. Fig. 4. Shows the effect of air velocity on the drying efficiency. The system drying efficiency increases as the air velocity increases. This clearly shows the relevant of the dryer performance on the air velocity. Dryer is tasted with natural circulation and forced circulation through dryer which effects the drying efficiency. Efficiency founds when air flows naturally through vents, it is around 10 m/s to 35 m/s, whereas it is found in the range of 15 m/s to 54 m/s. during air flows or forced to flow through dryer by fan /blower.

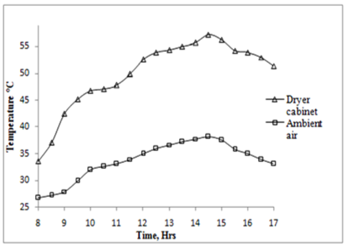

Fig 2: Temperature variation during test

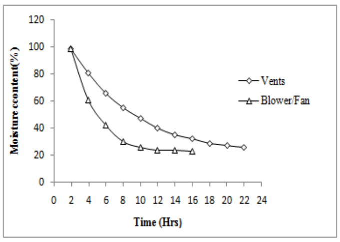

Fig 3: Moisture content variation with time

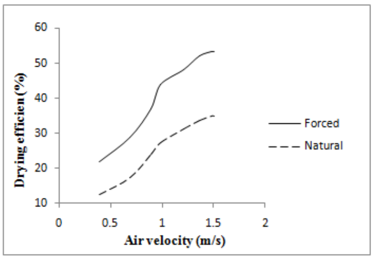

FIG 4: Efficiency variation with air velocity

IV. CONCLUSION

In this work, practical way of low cost preserving food items by the use of solar dryer has been experimented. The fabrication of the dryer does not require high technology and once installed the maintenance cost is minimum. The dryer was tested and the following conclusions can be drawn based on the results obtained, the maximum drying air temperatures was found to be 57°C inside the dryer cabinet. The average drying air temperature in the drying cabinet was higher than the ambient temperature in the range of 5°C in the early hours of the day to 20-25°C at mid-day. The average temperature in the drying cabinet was also found higher than that of the air-heater in the range of 2-5°C, which justified the additional heat received from direct solar radiation through the transparent walls. About 80% and 55% weight losses were obtained in the drying of pepper and yam chips, respectively, in the dryer. In the two cases, the use of the dryer led to considerable reduction in drying time in forced circulation in comparison to the natural circulation drying. The system efficiency increased as the air velocity increased.

REFERENCES

[1] Adom, K.K., Dzogbefia, V.P. and Ellis, W.D. (1997), Effect of drying time and slice thickness on the solar drying of okra, Journal of Science of Food and Agriculture, 73(3), 315-320.
[2] Ajao, K.R. and Adegun, I.K. (2009), "Performance evaluation of a locally fabricated mini cassava flash dryer", Journal of Agricultural Technology, Vol.5, pp.281-289
[3] Arinze, E.A. (1985a), "Design and simulation of a solar energy crop drying and thermal storage system", Nigeria Journal of Solar Energy, Vol.4, pp.36-52
[4] Arinze, E.A. (1985b), "Design and performance evaluation of a commercial size natural convection solar crop dryer", Nigeria Journal of Solar Energy, Vol.4, pp.106-115
[5] Arun S. Mujumdar & Chung Lim Law 'Drying Technology: Trends and Applications in Postharvest Processing' Food Bioprocess Technol (2010) 3:843–852.
[6] Askari, G. R., Emam-Djomeh, Z., & Mousavi, S. M. (2009). An investigation of the effects of drying methods and conditions on drying characteristics and quality attributes of agricultural products during hot air and hot air/microwave-assisted dehydration. Drying Technology, 27, 831–841.
[7] Bala, B. K., Mondol, M. R. A., Biswas, B. K., Das Chowdury, B. L., & Janjai, S. (2003). Solar drying of pineapple using solar tunnel drier. Renewable Energy, 28(2), 183–190.
[8] Beaudry C, Raghavan GSV, Ratti C, Rennie TJ (2004) Effect of four drying methods on the quality of osmotically dehydrated cranberries. Drying Technol 22:521–539
[9] Bhosale, B.S. and Arya, A.B. (2004), Effect of different modes of drying on moisture content and drying time of the selected vegetables, The Indian Journal of Nutrition and Dietetics, 41, 293.
[10] B. O. Bolaji, Tajudeen M.A. Olayanjub and T.O. Falade, Performance Evaluation of a Solar Wind-Ventilated Cabinet Dryer ,The West Indian Journal of Engineering Vol.33, Nos.1/2, January 2011, pp.12-18
[11] I.Domyaz, Drying of green bean and okra under solar energy CI&CEQ 17(2) 199-205(2011)
[12] Itodo, I.N., Obetta, S.E. and Satimehin, A.A. (2002), "Evaluation of a solar crop dryer for rural application in Nigeria", Botswana Journal of Technology, Vol.11, pp.58-62
[13] Jayaraman, D.K., Das Gupta and N. Babu Rao (1991), Quality characteristic of some vegetables dried by direct and indirect sun drying, Indian food packer, 45, 18-23.
[14] K.R. Ajao , A.A. Adedeji, Assessing the Drying rates of some Crops in Solar Dryer. Journal of Research information in Civil Engineering, Vol.5, No.1, 2008
[15] Kudra, T., & Mujumdar, A. S. (2001). Advanced drying technologies (pp. 81–111). New York: Marcel Dekker.
[16] Mujumdar, A. S. (1991). Drying technologies of the future. Drying Technology, 9, 325–347.
[17] Mujumdar, A. S. (2007c). Superheated steam drying. In A. S. Mujumdar (Ed.), Handbook of industrial drying (pp. 439– 452). Boca Raton: CRC
[18] P.K.Wankhade, R.S.Sapkal, V.S.Sapkal, Drying Characteristics of Okra Slices using Different Drying Methods by Comparative Evaluation, WCECS 2012, October 24-26, 2012, San Francisco, USA pp 757-760.
[19] S. H. Sengar , A. G. Mohod , & Y. P. Khandetod, Experimental Evaluation of Solar Dryer for Kokam Fruit, Global Journal of Science Frontier Research Agriculture & Biology Volume 12 Issue 3 Version 1.0 March 2012
[20] Schirmer, P., Janjai, S., Esper, A., Smitabhindu, R., & Mu¨hlbauer, W. (1996). Experimental investigation of the performance of the solartunnel dryer for drying bananas. Renewable Energy, 7(2), 119–129.
[21] Tiris, C., Tiris, M., & Dincer, I. (1996). Energy efficiency of a solar drying system. International Journal of Energy Research, 20(9), 767- 770.