Drying Characteristics of Okra Slices using Different Drying Methods by Comparative Evaluation

P.K.Wankhade, R.S.Sapkal, V.S.Sapkal.

Abstract: Drying is an essential process in the preservation of agricultural products. Various drying methods are employed to dry different agricultural products. Each method has its own advantages and limitations. Choosing the right drying system is thus important in the process of drying agricultural products. Care must be taken in choosing the drying system. Study comparing traditional drying and other drying methods for the reduction of the drying time and to a significant improvement of the product quality in terms of color texture and taste. Drying reduces the possibilities of the contamination by insects and microorganisms so that product is prevented. An experimental study was performed to determine the drying characteristics of okra using hot air dryer, solar dryer and open sun drying methods. For the hot air drying, the test samples were dried in a laboratory scale hot air dryer at a constant air velocity of 1 m/s and air temperature in the range of 40–90 ℃. For solar drying experiments locally made a solar dryer with vents for natural convection type is used.

Some are the important commercial agricultural product grown in India. As it is seasonal in nature its availability is limited only to some part of the year. Okra is harvested at green, tender stage; hence it cannot be stored for longer period. Drying is the most widely used and a primary method for preservation. In this connection investigations were carried out to study the effect of drying on storage and quality of okra to make it available in off season. Results indicated that okra dried at 40℃ - 90℃ under hot air drying recorded and dried in open sun drying and solar drying, comparative evaluation is made from the characteristics and its drying curves. It suggests drying of okra will be under proper and controlled method will have better quality and longer storage period.

Keywords: Drying, product quality, moisture content, hot air dryer, solar dryer.

I. INTRODUCTION

DRYING is a heat and mass transfer process resulting in the removal of water moisture, by evaporation from a solid, semi solid or liquid to end in a solid state. The drying technique is probably the oldest and the most important method of food preservation practiced by humans. The removal of moisture prevents the growth and reproduction of microorganisms which cause decay, and minimizes many of the moisture-mediated deteriorative reactions. It brings about substantial reduction in weight and volume, minimizing packing, storage and transportation costs and enables storability of the product under ambient temperatures (Mujumdar, 1995). During drying many changes take place; structural and physic-chemical modifications affect the final product quality, and the quality aspects involved in dry conversion in relation to the quality of fresh products and applied drying techniques. Currently hot air drying is the most widely used method in post-harvest technology of agricultural products. Using this method, a more uniform, hygienic and attractively colored dried product can be produced rapidly. However, it is an energy consuming operation and low energy efficiency, so more emphasis is given on using solar energy sources due to the high prices and shortage of fossil fuels. Solar dryers are now being increasingly used since they are a better and more energy efficient option. The solar dryers could be an alternative to the hot air and open sun drying methods, especially in locations with good sunshine during the harvest season (Pangavhane, Sawhney, & Sarsavadia, 2002). Among these are lacks of ability to control the drying process properly, weather uncertainties, high manpower costs, large area requirement, insect infestation, mixing with dust and other foreign materials and so on.

Solar drying is essential for preserving agricultural products. Using a solar dryer, the drying time can be shortened by about 65% compared to sun drying because, inside the dryer, it is warmer than outside; the quality of the dried products can be improved in terms of hygiene, cleanliness, safe moisture content, colour and taste; the product is also completely protected from rain, dust, insects; and its payback period ranges from 2 to 4 years depending on the rate of utilization. The most important feature of solar dryers is that the product does not include any kind of preservatives or other added chemical stuffs, which allows its use for people suffering from various allergic reactions from chemical preservatives and other added stuffs. Furthermore, the product is not exposed to any kind of harmful electromagnetic radiation or electromagnetic poles (Tiris, Tiris, & Dincer, 1996). Therefore, solar dryer may become a more convenient alternative for rural sector and other areas in which electricity is scarce and in regular supply. Also, it can reduce crop losses, improve the quality

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of dried product significantly and is economically beneficial compared to traditional drying methods.

Vegetables and fruits are indispensable part of human diet and can be regarded as the fuel for physiological processes. 25-30% of total produce is being wasted during handling from point of production to consumer's plates. This wastage can be effectively reduced by applying appropriate method of processing and preservation. In this regard some of the vegetables have been traditionally processed by drying to extend their storage life well beyond few weeks and make it available in off season.

II. OBJECTIVE

Okra is one of the fruit vegetable, normally consumed as a vegetable in large scale throughout India and other parts of the world. The immature, fresh and tender fruits which are generally cooked as vegetable for culinary and soup purposes. The fruits also have some medicinal value and provide moderate amount of vitamins, dietary fiber, energy and minerals. They may also be dried and ground into the powder and added for flavoring in various dishes. In India okra is traditionally preserved by slicing and sun drying on the ground, concrete floors, racks, trays and other drying surfaces up to 5-6 days till it becomes brittle. (Kalra and Bharadwaj 1981). The present investigation was carried to find out the most effective drying method for storage and organoleptic qualities of okra.

The efficient processing and long-term storage of okra requires that the moisture content be reduced to suitable levels by various drying methods. Therefore, the present study was conducted with the objectives:
To study and compare the drying characteristics of okra using the open sun, solar dryer and hot air drying methods and to fit the experimental data obtained to describe drying behavior of agricultural products.

III. MATERIALS AND METHODS

1. Material

The experiment was conducted on effect of drying on storage and dried quality of okra. The fresh okra fruits were collected from local market during Feb- March. The average dimensions of fruit vegetable were 60-80 mm long and 15-20 mm average diameter, dark green colored fruits were selected for the study. The fruits vegetable were thoroughly washed and sliced into 5 mm thickness using sharp sterilized knife.

2. Experimental set up

The experimental set ups used for determining the influence of various drying methods on the drying behavior of okra. 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 m^2, 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.

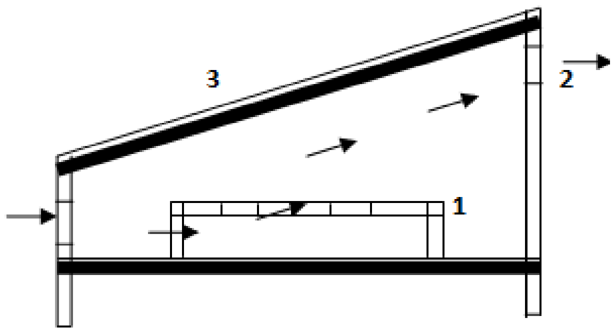

FIG1: Schematic Diagram of Solar Dryer
1. Wire mesh platform, 2.Vent for air flow
3. Glass cover

3. Method

The slices were then weighed exactly 100 gms for each treatment. These were kept for drying in three replications. The hot air drying was carried by drying the samples at 40°C, 60°C and 90°C air temperatures and a constant air velocity of 1 m/s. For sun drying the weighed okra slices were taken in paper plates and kept on the open floor on the top of terrace. For solar drying the weighed okra slices were taken in paper plates and kept inside the solar dryer platform. The hot air drying was carried out by keeping the weighed slices in steel plates. Observations on physiological loss in weight and colour change in each sample were recorded at the particular interval of in sun drying 1 hrs, 1 hour in solar drying and 10-20 minutes for hot air 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 the open sun drying and solar drying was recorded throughout the drying period using hygro-thermometer.

The hot air drying experiments were conducted at 40, 60 and 90 °C air temperatures and a constant air velocity of 1 m/s. In each experiment, about 100 g of okra samples were used. Moisture losses of samples were recorded at 10 min intervals for first one hour and 20 min subsequently thereafter for determination of drying curves.

The open sun and solar drying experiments were carried out during the periods of February-March under the clean climatic conditions of Vidarbha. Each experiment

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started at 8:00 am and continued till 6:00 pm. To determine the moisture loss of drying samples during experiments, okra 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. The moisture loss of samples was determined with the help of a digital electronic balance having an accuracy of 0.01 g. 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. Also, to compare the performance of the solar dryer with that of open sun drying, both samples were dried simultaneously under the same weather conditions.

4. Drying analysis:
4.1 Moisture content:

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

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

4.2 Drying rate (Rd):

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

4.3 Moisture ratio is given by,

$$\mathrm{MR} = \frac{M - Me}{Mci - Me}$$

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

IV. RESULT AND DISCUSSION

The effect of different drying methods 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. Time required for open sun drying of okra was 23 hours and solar drying took 15 hours, where as hot air drying was found to be quicker drying method. It took lesser time of about 470 minutes at 40°C air temperature, 250 minutes at 60°C air temperature and 100 minutes at 90°C air temperature to attain final constant weight.

The results pertaining to drying of okra as recorded in three different methods *viz*, open sun drying, solar drying and hot air drying are shown in fig. 2 and 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 reduction in moisture content of okra during first hour in hot air drying and solar drying was at higher rate than the samples dried in open sun drying condition. Similar trend was also observed by Bhosale and Arya (2004), in cabbage, cluster bean, fenugreek, spinach and okra. Among the drying methods the removal of moisture from okra slices was found to be at faster rate in hot air drier followed by solar drying and open sun conditions. This was attributed to the level of temperature and rate of air flow in the dryer which might be responsible for higher difference in loss of moisture. Differences in final weight were observed with the samples dried under different methods of drying. The final weight achieved were, 15.6 gm under solar drying, 16.1 gm in open sun drying. Similarly final weight recorded with different levels of air temperature under hot air drying were 15.6 gm, 14.98 gm and 13.39 gm at the air temperature of 40°C, 60°C and 90°C respectively.

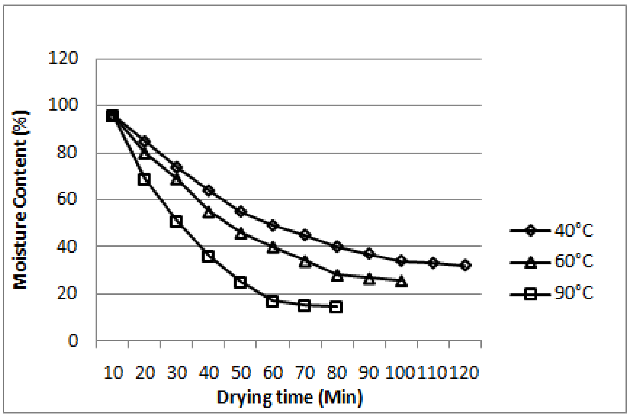

Fig. 2: Drying curve of hot air dryer temperature of dried okra slices.

Further the textures of final dried samples were also recorded. Result indicated that the slices dried under hot air dryer at 40°C air temperature remained their texture well. The slices dried at 90°C had poor textural quality and were shriveled and giving burnt appearance. The sundried slices were also appeared shriveled with broken pieces.

Hot air drying of okra the moisture content versus drying time curves as affected by various air temperatures are shown in Fig. 2. The samples of average initial moisture content of around 67 gm were dried to the final moisture content of about 15.6 gm until no further changes in their mass were observed. It is evident from these curves that the moisture content decreases continuously with the drying time. As expected, the air temperature had a significant effect on the moisture content of samples. Solar drying of okra Fig. 3 shows the variations of the ambient air temperature, relative humidity and solar radiation during the solar dryer and open sun drying of okra in the day.

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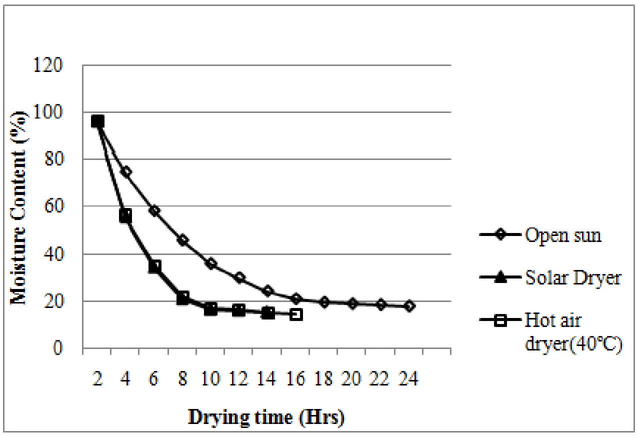

Fig. 3: Drying curve of different drying techniques of dried okra slices.

During the drying experiments, the weather was generally sunny. The ambient air temperatures were reached the highest figures between 11:00 and 16:00. Inside the solar dryer, it is warmer than outside. This clearly indicates that the drying rate in the solar drying would be higher than open sun drying. Fig. 2 suggests drying curves for okra dried by solar dryer and open sun drying methods. Whereas the drying is smooth and controlled by temperature variation using hot air dryer.

Drying rate goes on decreasing with decrease in moisture content as shown in Fig. 4. And it appears to be smooth and controlled in hot air dryer than in open sun and solar dryer.

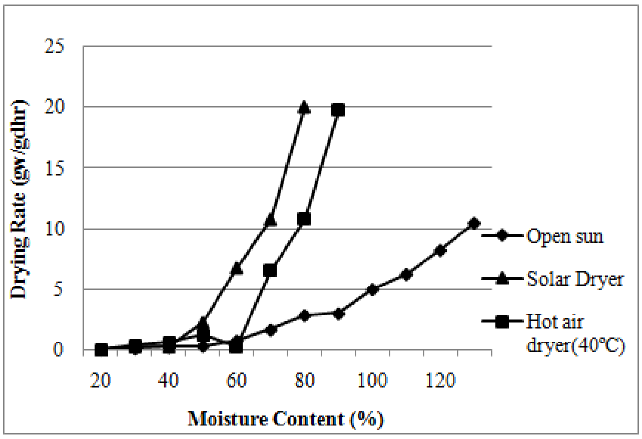

Fig. 4: Drying rate of different drying techniques on respective moisture content of dried okra slices.

Further the observations were also recorded on change in colour of the dried okra slices. The change of colour from green to light green was observed with solar drying. The change of colour in hot air dryer at 90℃ air temperature was brownish and dark brown respectively. Whereas the colour was found to be better (green) at 40℃ air temperature in hot air dryer.

V. CONCLUSION

The three drying methods used greatly affected the drying characteristics okra. The solar dryer was found to be more efficient than the open sun drying. In addition, the samples of solar dryer were completely protected from insects, birds, rain and dusts. The commonly consumed okra was dried under conventional drying, sun drying and open sun drying. The drying characteristic and time required for drying of okra was studied and final dry weight of the okra slices were estimated. It was found that okra samples, dried by hot air drying were reported to take minimum time for drying with maximum removal of moisture. The initial first hour of hot air drying and sun drying and initial 6 hours under open sun drying resulted in maximum removal of moisture from okra. The okra slices dried in hot air dryer at 40℃ gives better results in maintaining better appearance, colour and texture.

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