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Research Paper :

Comparative study of Aonla drying by natural, solar and mechanical methods

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ABSTRACT

Aonla (*Phyllanthus emblica*,L. Or *Emblica officinalis*,G.) is important tropical and subtropical deciduous tree of commercial importance. Total area of this crop under cultivation throughout india is 49.62 thousand ha while total production of Aonla is 111.10 thousand metric tonns. Aonla is valued for nutritional and medicinal properties. It is also useful in Ayurvedic and unani system of Indian medicines. The local variety of Aonla was selected for studies of drying characteristics. The drying of Aonla was undertaken in the form of slices and shreds. Three difference treatment used were natural drying, solar drying and mechanical drying (at 50^0C, at 55^0C, at 60^0C). The different drying curves were analyzed and value of drying constant for each treatment was calculated. Different engineering properties were analysed before and after drying. Bulk density was found o be 1368.93 kg/m^3 and 324.86 Kg/m^3, True density was 2747.46 Kg/m^3 and 1444 Kg/m^3 and porosity was found to be 50.72% and 78.72% before and after drying. Heat utilization factor for solar drying was 0.6568 and for mechanical drying it was 0.2808. The value of drying constant was found 1.0247 hr^{-1} for mechanical drying of Aonla slices at 50^0 C and 0.9556 hr^{-1} for solar drying of Anola shreds. Organoleptic evaluation was undertaken to evaluate the effect of different drying methods and temperature combination for Aonla slices and shreds considering all aspects such as colour, texture and test.

Key words : Aonla, Dehydration, Solar drying, Natural drying, Mechanical drying

Aonla is botanically classified as *Phyllanthus emblica*, L. or *Emblica officinalis*, G. It is also known as Indian goose berry, helli, amalkamu or amla. It is one of the important tropical and subtropical deciduous tree of commercial importance. It belongs to family Euphorbiaceae (Tripathi *et al.*, 1988).

Aonla fruits get ready for harvesting in November to December. But fruits may be allowed to remain on tree until February without fruit drop. The optimum stage of harvesting falls between second week of December to third week of January (Ram *et al.*, 1983). Fully grown tree yields 2.5 to 3 quintals of fruits per year (Kalra, 1988).

Total area of this crop under cultivation throughout India is 49.62 thousand ha while total production of Aonla is 111.10 thousand metric tonnes. While in case of Maharashtra it occupies an area of 4.00 thousand ha and contributing production of 5.6 thousand metric tonns with the productivity of 1.4 t/ha. (Market Survey of Aonla, UPLDC – Nov. 2002).

Aonla fruit is a rich source of ascorbic acid and contains about 20 times more vitamin C than citrus fruit (Chadha, 1992). The fruit contains 450 –682 mg/100 gm ascorbic acid, moisture 81.2 per cent, reducing sugars 5.57 per cent, starch 3.00 to 7.23 per cent and small amount of calcium, phosphorus, iron, nicotinic acid, thiamine and tannin (Shrivastava and Shrivastava, 1964; Teotia *et al.*, 1968; Gopalan, 1971; Ram *et al.*, 1983; Deb and Chandrasekhar, 1960).

Aonla is valued for nutritional and medicinal properties. The fruit contains considerable amounts of polyphenols that retard the oxidation of ascorbic acid. Aonla is valued as an antiscorbulic, diuretic laxative, alternative antibiotic and is used in treating chronic dysentery, bronchitis, dysperisa and cough. It is useful in Ayurvedic and Unani system of Indian medicines. (Khan and Moheet, 1958; Tripathi *et al.*, 1979)

The traditional methods of Aonla drying are cumbersome, unhygienic and laborious. These methods result into the contamination of products due to dust, ash, insects and birds. The open sun drying requires large drying time as well as it is an uncontrolled drying method and hence reduces cost of final products. In this context, present research study was carried out to reduce the processing losses during drying and to retain quality of dried products.

METHODOLOGY

Drying of aonla:

Freshly harvested Aonla fruits of local variety were taken for drying. They were firstly cleaned and then cut into slices and shreds of uniform size by means of knives and grater.

Natural drying:

Slices and shreds were sun dried for 34 hours and 12 hours, respectively to reduce moisture content to safe level of 6 to 7%. The weight loss of Aonla fruits were taken on hourly basis.

Solar cabinet drying:

Slices and shreds were kept on the trays of solar cabinet dryer for 27 hours and 6 hours, respectively. Temperatures of drying air, inlet air and exhaust air were taken with the help of thermometer for calculation of heat utilization factor. The weight loss of Aonla fruits were taken on hourly basis.

Mechanical drying:

The weighed Aonla sample in the form of slices and shreds were loaded for drying in tray dryer. Environmental parameters such as humidity, dry bulb temperature of exhaust and inlet air were measured. Weight loss of Aonla fruits was measured on hourly basis. This procedure was repeated for 50^{0}C, 55^{0}C and 60^{0}C temperature.

Initial moisture content:

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

$$\text{M.C. (d b)} = \frac{W_1 - W_2}{W_2}$$

where,
W_1 = Weight of wet sample gm
W_2 = Weight of bone dry sample gm

Drying was carried out by keeping Aonla in tray dryer. The drying of nutmeg was carried out at 50^{0}C, 55^{0}C and 60^{0}C temperature. The fruits were dried up to the final moisture content of 6% to 7%. The moisture removal from Aonla was determined by measuring loss in weight at an interval of one hour. The corresponding environmental parameters were also measured at the same time.

Drying rate:

From the weight taken after every one hour interval moisture loss and drying rate were calculated.

$$DR = \frac{W_m}{T}$$

where,
DR = drying rate, (gm/hr/100 gm of bone dry wt)
W_m = Wt loss in one hour interval (gm/100 gm of bone dry wt)
T = Time interval, hr.

Moisture ratio:

$$MR = \frac{M - M_e}{M_0 - M_e}$$

where,
M = Moisture content (d b), %
M_e = Equilibrium moisture content (d b), %
M_o = Initial moisture content (d b), %
Heat utilization factor

It was determined by recording temperature of drying, inlet and exhaust air with the help of thermometer.

$$HUF = \frac{t_1 - t_2}{t_1 - t_0}$$

t_1 = Temperature of drying air.
t_2 = Temperature of exhaust air.
t_0 = Temperature of ambient air.

RESULTS AND DISCUSSION

The chapter describes the results of the experiment in three sections. The first section deals with the engineering properties. The second section describes the drying evaluation of dried Aonla. Various gravimetric properties and performance characteristics of drying methods were determined. Aonla fruits were treated at 50°C, 55°C, 60°C and from these treatments an optimum temperature was found out.

Drying characteristics of aonla slices:

Drying characteristics of naturally dried aonla slices:

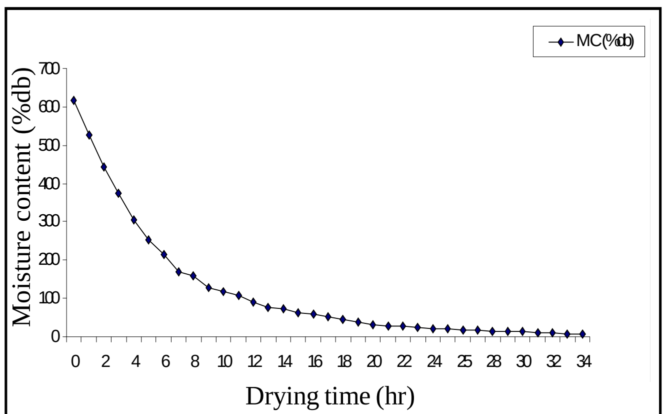

Fig. 1 : Moisture content verses drying time for naturally dried Aonla slices

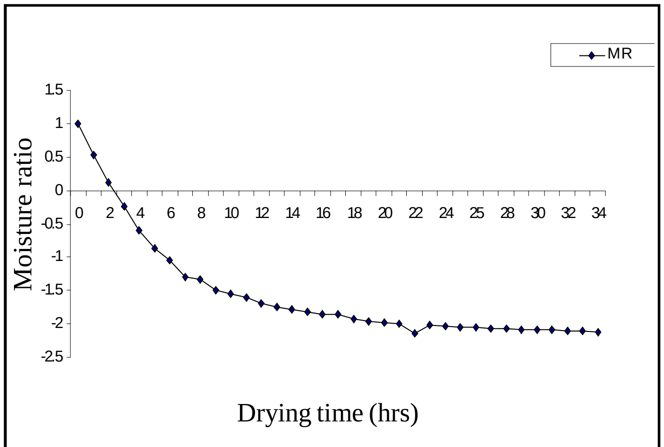

Fig. 2 : Moisture ratio verses drying time for naturally dried Aonla slices

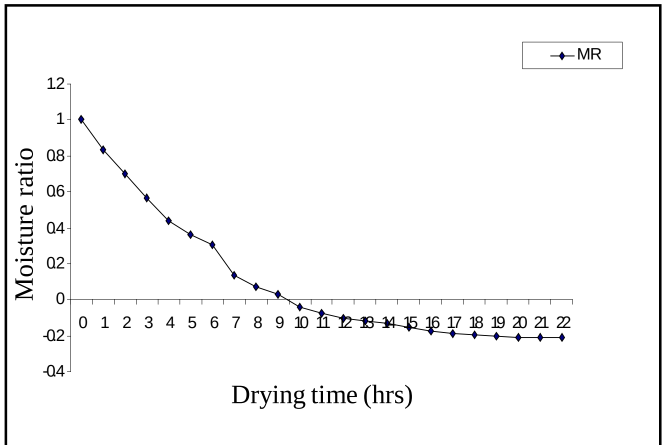

Fig. 5 : Moisture ratio verses drying time for solar dried Anola slices

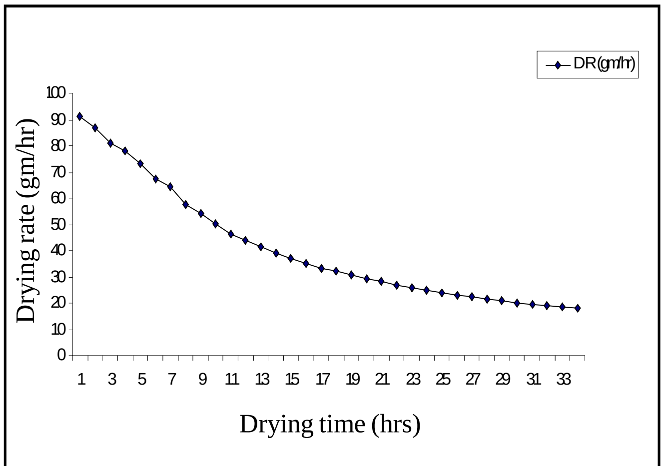

Fig. 3 : Drying rate verses drying time for naturally dried Aonla slices

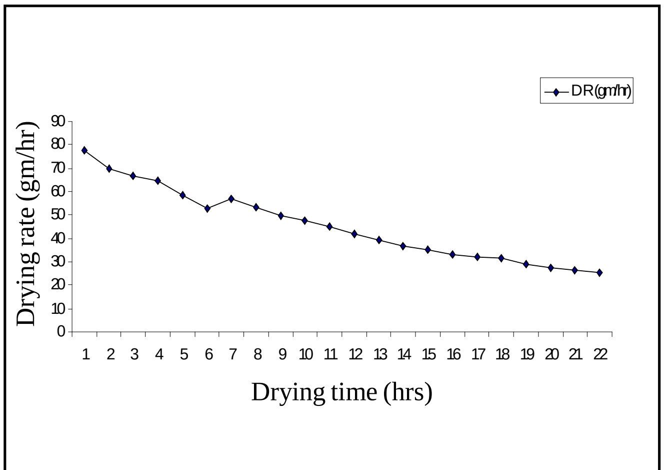

Fig. 6 : Drying rate verses drying time for solar dried Aonla slices

Drying characteristics of solar dried Aonla slices:

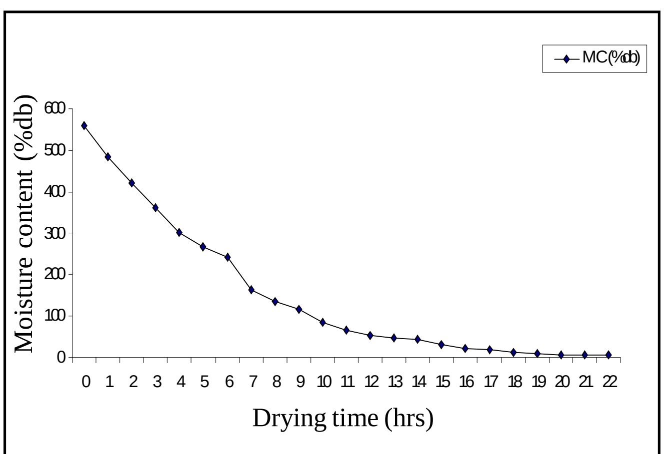

Fig. 4 : Moisture content verses drying time for solar dried Aonla slices

Drying characteristics of mechanically dried Aonla slice:

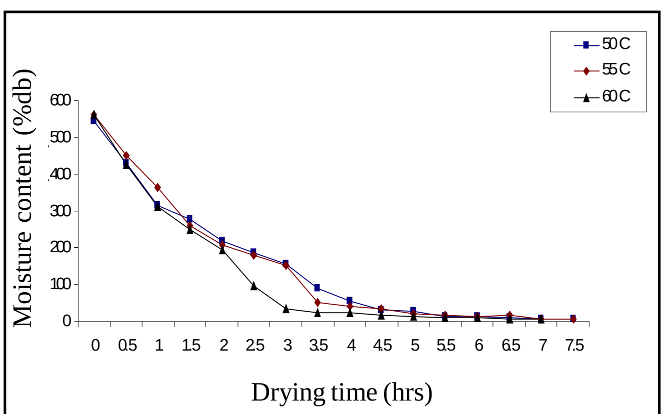

Fig. 7 : Moisture content verses drying time for mechanically dried Aonla slices

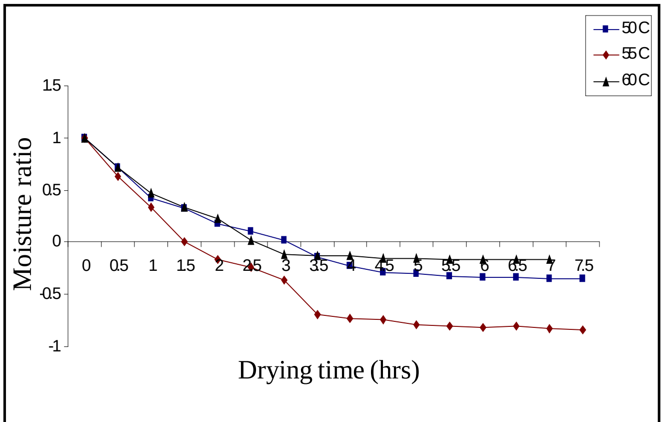

Fig. 8 : Moisture ratio verses drying time for mechanically dried Aonla slices

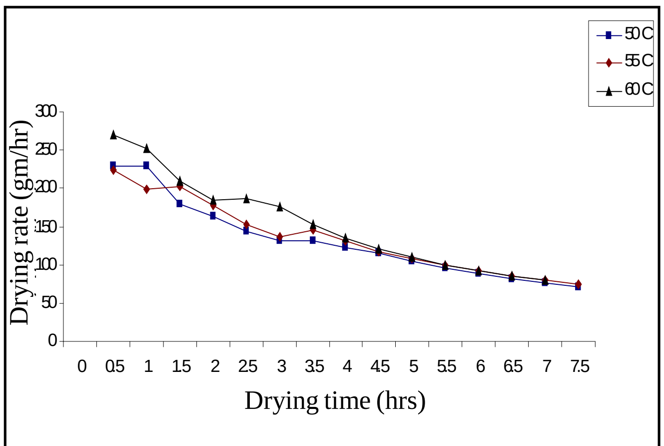

Fig. 9 : Drying rate verses drying time for mechanically dried Aonla slices

Interpretation from the drying curves for Aonla slices:

The equation for moisture content at particular time was determined by minimizing the error and the best-fit exponential equation was obtained as $M = 530.46e^{-0.1264t}$. Using this exponential equation, data of moisture content for naturally dried Aonla slices was predicted and was compared with experimental data. The predicted and the experimental values of moisture are in good agreement. The correlation coefficient R^2 was 0.9909 indicating that model fits the experimental data.

Effect of drying time on drying rate:

The drying rate is dependent upon many factors, namely air temperature, air flow rate, relative humidity, exposure time, type of variety and size of grain, initial moisture content, grain depth etc.

The curvilinear regression equation was determined minimizing the error and the best–fit exponential equation was obtained as $DR=321.6e^{-0.0954t}$ for mechanically dried Aonla slices for 60°C. The Table 9 shows correlation coefficient R^2 was 0.9911 indicating that model fits the experimental data.

Drying Characteristic of Aonla Shreds

Drying characteristics of naturally dried Aonla shreds:

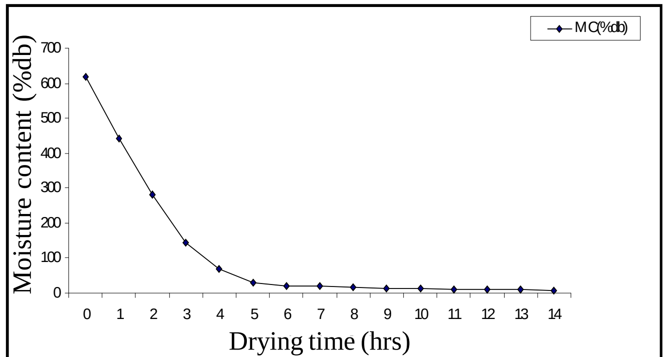

Fig. 10 : Moisture content verses drying time for naturally dried Aonla shred

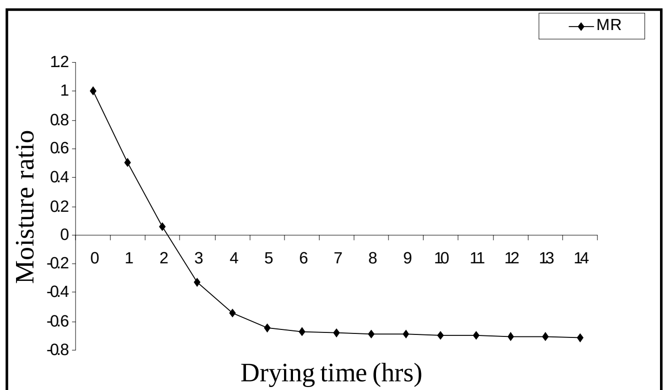

Fig. 10 : Moisture content verses drying time for naturally dried Aonla shred

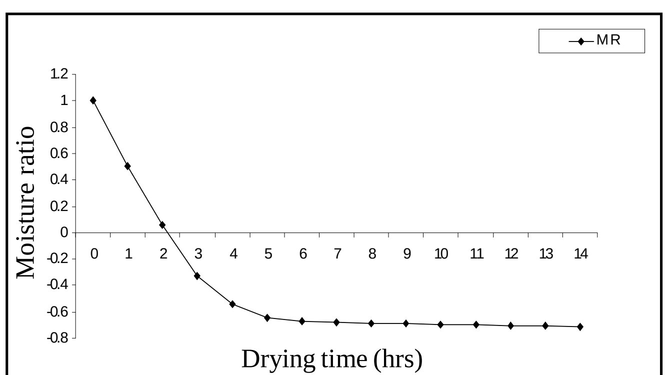

Fig. 11 : Moisture ratio verses drying time for Naturally dried Aonla shreds

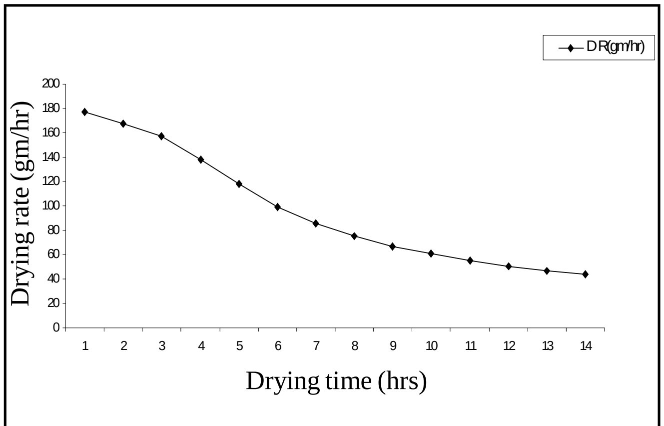

Fig. 12 : Drying rate verses drying time for naturally dried Aonla shreds

Drying characteristics of solar dried Aonla shreds:

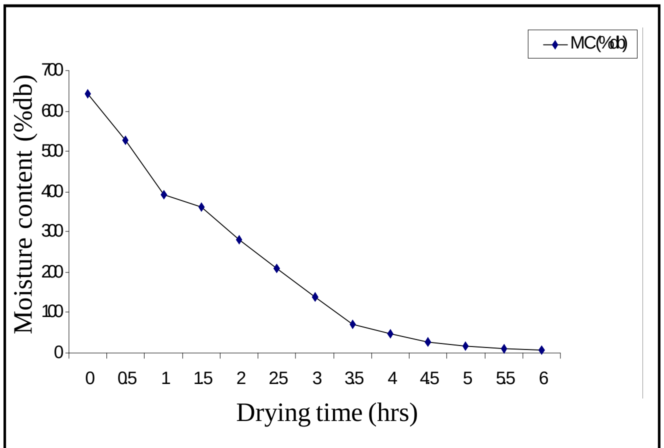

Fig. 13 : Moisture content verses drying time for solar dried Aonla shreds

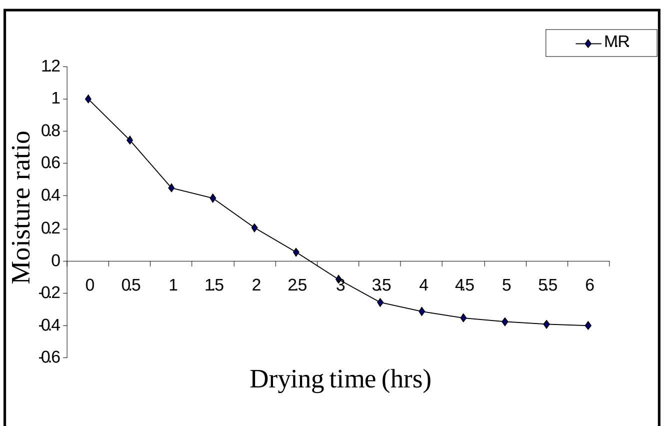

Fig. 15 : Drying rate verses drying time for solar dried Aonla shreds

Drying characteristics of mechanically dried Aonla shreds:

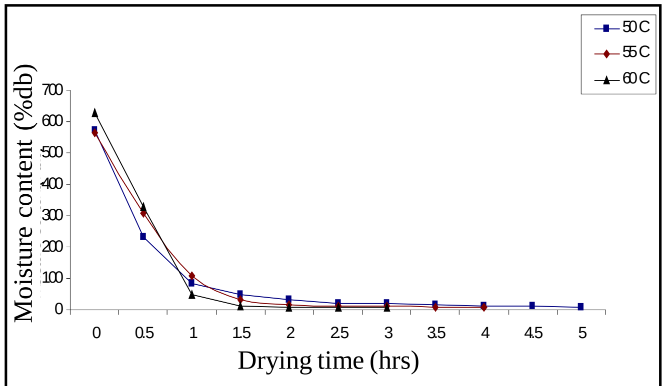

Fig. 16 : Moisture content verses drying time for mechanically dried Aonla shreds

Interpretation from the drying curves for Aonla shreds:

The equation for moisture content at particular time was determined by minimizing the error and the best-fit polynomial equation was obtained as $M = 5.0864t^2 - 123.56t + 754.65$. Using this polynomial equation, data of moisture content for solar dried Aonla shreds was predicted and was compared with experimental data as shown in Table 20. The Table 14 shows correlation

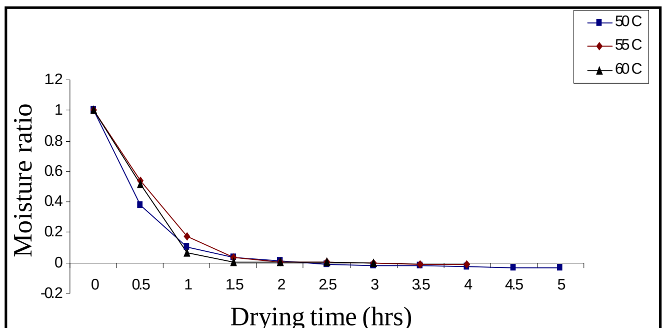

Fig. 17 : Moisture ratio verses drying time for mechanically dried Aonla shreds

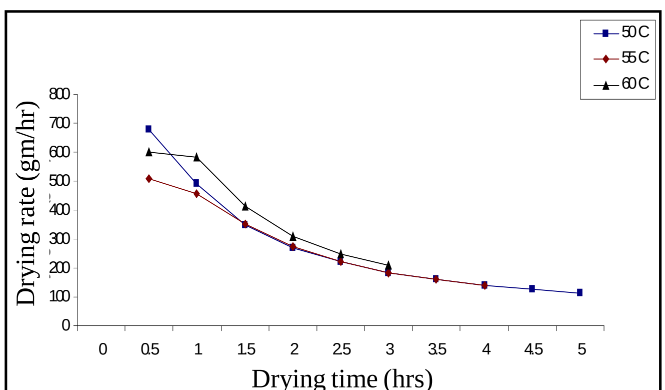

Fig. 18 : Drying rate verses drying time for mechanically dried Aonla shreds

coefficient R^2 was 0.9948 indicating that model fits the experimental data.

Effect of drying time on drying rate:

The drying rate is dependent upon many factors, namely air temperature, air flow rate, relative humidity, exposure time, type of variety and size of grain, initial moisture content, grain depth etc.

The curvilinear regression equation was determined minimizing the error and the best fit exponential equation was obtained as $DR = 250.39e^{-0.0627t}$ for solar dried Aonla shreds. The Table4.16 shows correlation coefficient R^2 was0.9706 indicating that model fits the experimental data.

Analysis of drying constant:

Naturally dried Aonla slices:

As we can observe in Fig 4.2 the graph of moisture ratio verses drying time for naturally dried Aonla slices approached to zero value very earlier. Hence we were unable to plot graph of moisture ratio verses drying time on semi log paper due to insufficient no of readings.

Solar dried Aonla slices:

The graph of moisture ratio verses drying time for solar dried Aonla slices was plotted on semi log paper in Fig 4.19. From analysis of this graph value of drying constant was calculated. It was found to be 0.3147 hr^{-1}.

Mechanically dried Aonla slices:

The graphs of moisture ratio verses drying time for mechanically dried Aonla slices for 50°C, 55°C and 60°C were plotted on semi log paper in Fig 4.20, Fig 4.21 and Fig 4.22, respectively. From analysis of these graphs value of drying constant was calculated for each treatment. It was found to be 1.0247 hr^{-1}, 0.7714 hr^{-1} and 0.8612 hr^{-1} for 50°C, 55°C and 60°C, respectively.

Naturally dried Aonla shreds:

As we can observe in Fig 4.11 the graph of moisture ratio verses drying time for naturally dried Aonla shreds approached to zero value very earlier. Hence we were unable to plot graph of moisture ratio verses drying time on semi log paper due to insufficient no of readings.

Solar dried Aonla shreds:

The graph of moisture ratio verses drying time for solar dried Aonla shreds was plotted on semi log paper in Fig 4.23. From analysis of this graph value of drying constant was calculated. It was found to be 0.9556 hr^{-1}.

Mechanically dried Aonla shreds:

The graphs of moisture ratio verses drying time for mechanically dried Aonla shreds for 50°C, 55°C and 60°C were plotted on semi log paper in Fig 4.20, Fig 4.21 and Fig 4.22, respectively. From analysis of these graphs value of drying constant was calculated for each treatment. It was found to be 0.4329 hr^{-1}, 0.3845 hr^{-1} and 0.3228 hr^{-1} for 50°C, 55°C and 60°C, respectively

Conclusions:

Following are the specific conclusions that emerged from the present study.

– The gravimetric properties such as bulk density and true density were found to decrease after drying and in both the cases maximum decrease was observed in case of solar drying. This decrease in bulk as well as true density after drying is of greater importance from packaging point of view.

– The value of porosity was found to be increased after drying. The maximum increase was observed in case of mechanical drying which indicates the suitability of this drying method for further processing.

– The heat utilization factor was higher for solar drying than for mechanical drying. It is due to improper air circulation in mechanical dryer which was used in this study.

– The moisture content verses drying time curve as well as moisture ratio verses drying time curve showed best fit in curvilinear regression equation while the drying rate verses drying time curve showed best fit in exponential equation.

– Mostly drying was accomplished in falling rate period rather than constant rate period. For drying of Aonla shreds, first falling rate period was smaller than second falling rate period as compared with drying of Aonla slices.

For Aonla slices the value of drying constant was found to be maximum in mechanical drying at 50°C and for Aonla shreds the value of drying constant was found maximum for solar drying.

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