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Effect of moisture content and drying rate on dried aonla shreds during ambient storage

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Abstract
The drying behavior of aonla shreds were analyzed using the experimental data of moisture of product at different temperatures viz. 60ºC, 70ºC and 80ºC under cabinet dryer, hot air oven and osmo-air drying. It was found that the drying time of the blanched+ sulphiting aonla shreds samples were less than the controlled and blanched aonla shreds sample at 60ºC, 70ºC and 80ºC respectively. Osmosis as a pretreatment prior to convective air drying was able to decrease drying time. The blanching + sulphiting aonla shred samples with osmotic pre-treatment were more appreciable in comparison to controlled and blanched aonla shred under cabinet tray dryer and hot air oven dryer on the basis of moisture content and drying rate.

Keywords: aonla shreds, osmosis, drying, blanching, sulphiting, moisture content and drying rate

Introduction
Aonla commonly known as Indian Gooseberry finds a special place in India as it has got tremendous medicinal values. Aonla is an important fruit crop of tropical and subtropical region of India. India with the production of Aonla is about 12, 66,460 MT in the area of about 1, 08,060 hectares (Anonymous, 2014) [2]. Amla also known as Indian gooseberry (*Emblica officinal is*), belongs to the family of Euphorbiaceous and is native to India, Sri-Lanka, Malaysia, Thailand. and China (Bhattacherjee *et al*., 2013) [3]. Amla is an underutilised fruit because its contribution towards the fruit production sector and the overall economy is small (Pathak, 2003) [9]. Drying is one of the oldest methods of food preservation and represents a very important aspect of food processing. Drying of food products is aimed at longer storage periods, lower packaging requirements and shipping weights (Okos *et al*, 1992; Kadam *et al*., 2005; Kadam *et al*., 2008) [8, 5, 6]. Osmotic dehydration is a process of partial removal of water by soaking foods, mostly fruits and vegetables, in hypertonic solutions (Shi and Maguer 2002) [12]. The driving force for the diffusion of water from plant tissue into solution is difference between osmotic pressures of hypertonic solution and plant tissue. The diffusion of water is accompanied by simultaneous counter diffusion of solutes from solution into tissue (Lazarides *et al*. 1995) [7].

Materials and methods
Mature aonla fruits, variety ‘Banarasi’ will be obtained from the Indian Institute farming research system, Modipuram, Meerut during the months of December to February, 2016. The experiments were conducted in the Department of Agricultural Engineering and Food Technology, S.V.P. University of Agriculture and technology, Meerut. It includes the preparation of dried aonla shreds under cabinet dryer, hot air oven and osmo-air drying at 60ºC, 70ºC, 80ºC at an interval of 60 min and observations were taken accordingly and determined their various quality parameters. The materials and methods used to conduct the present investigation are described in the following sections.

Drying characteristics: The drying behavior of aonla shreds was analyzed using the experimental data of moisture of product at various intervals and different temperatures viz. 60ºC, 70ºC and 80ºC. The experimental data of the drying behavior of aonla shreds with relation to moisture content, moisture ratio and drying rate. After applying selected pretreatment, the samples were dried up to the final moisture content level of 5.37 – 12.64 % on dry basis.

Osmo-air drying: The fruit pieces after removal of pits will be dipped in 70° Brix sugar solution for 17 hours at 50°C, drained, washed to remove adhering sugar, air dried and kept in hot air oven till no further moisture loss occurred.

Moisture content: Moisture content was determined by using air oven method (105+1°C) recommended by A.O.A.C. (1984) [1]. The following formulae were used to calculate the moisture content.

$$\text{MC, \% (d. b.)} = \frac{(W - Wd) \times 100}{Wd}$$

Where,
W = weight of sample at any time, g
Wd = Weight of bone dry matter, g
Weight of bone dry matter were calculated as

$$Wd = \frac{(100 - Mc) \times Wi}{100}$$

Where,
Wi = Initial weight of the sample, g
Mc = Moisture content of the sample, % (w.b.)

Drying rate: Drying rate was calculated by using following formula

$$\frac{dM}{dt} = \frac{M_i - M_{i+1}}{t_i - t_{i+1}}$$

Where, $\frac{dM}{dt}$ = drying rate, percent moisture loss per hour;
M_i= moisture content (% db) of sample at timet_i;
M_{i+1}= moisture content (% db) of sample at time t_{i+1}

Results and discussion

Variation of moisture content: The initial moisture content prior to drying was observed in the range 415.46-589.66 % (d.b.). The variation in moisture content with drying time is shown in Fig.1 to 9 at different temperatures. It was found that the drying time of the blanched + sulphiting aonla shreds samples were less than the controlled and blanched aonla shreds sample at 60ºC, 70ºC and 80ºC. Final moisture content of controlled, blanched and blanched + sulphiting aonla samples was found 12.64 %, 10.34% and 8.04%; 11.49%, 9.19% and 8.04%; 10.34%, 8.04% and 6.89% at 60ºC, 70ºC and 80ºC under cabinet tray dryer. For hot air oven drying Final moisture content of controlled, blanched and blanched + sulphiting aonla samples was found 13.79%, 12.64% and 11.49%; 10.34%, 8.04% and 5.74%; 11.49%, 6.89% and 8.04% at 60ºC, 70ºC and 80ºC. In osmo-air drying the final moisture content of controlled, blanched and blanched + sulphiting aonla samples was found to be 12.54%, 8.24% and 5.67%; 6.52%, 9.96 % and 6.52 %; 8.24%, 6.87% and 5.67% at 60ºC, 70ºC and 80ºC. Results of study revealed that the removal of moisture from the samples decreased gradually with increase in drying time to attain final moisture content. There is a non-linear decrease of moisture content with drying time. Initially the moisture content decreases rapidly with time and there after it becomes slower and slower and at last a stage comes when it becomes saturated. This is in accordance to kinetic theory that due to increase in temperature, energy of water molecules increases and hence, escaping of molecules becomes easier and faster from the medium (Prabhanjan *et al*., 1995) [10].

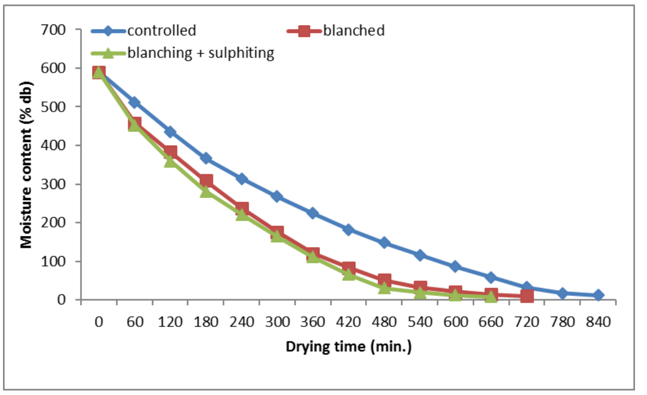

Fig 1: Variation in moisture content with drying time for aonla shreds under cabinet tray dryer at 60^0C.

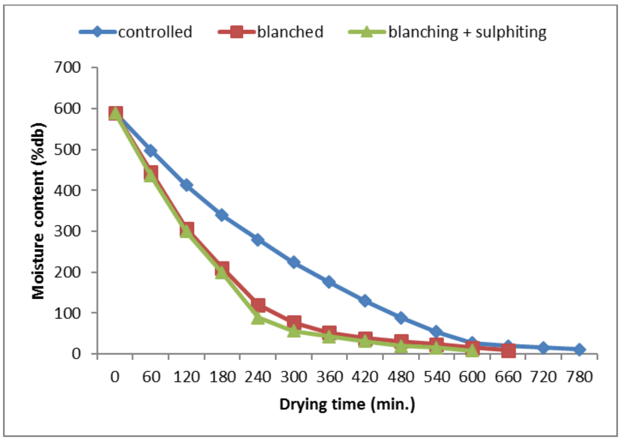

Fig 2: Variation in moisture content with drying time for aonla shreds under cabinet tray dryer at 70^0C.

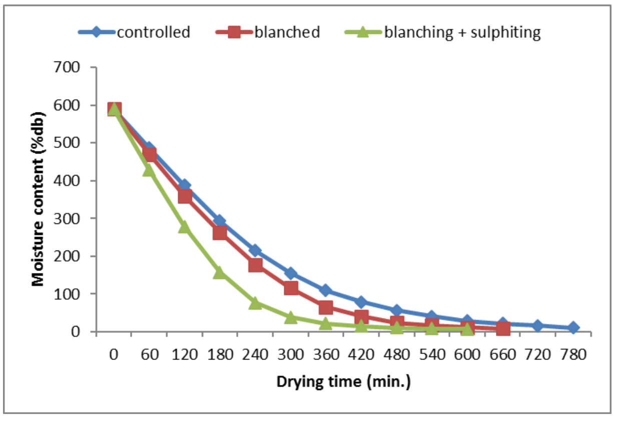

Fig 3: Variation in moisture content with drying time for aonla shreds under cabinet tray dryer at 80^0C.

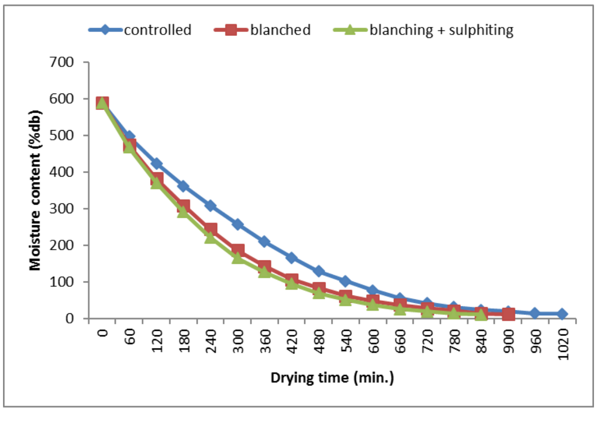

Fig 4: Variation in moisture content with drying time for aonla shreds under hot air oven at 60^0C.

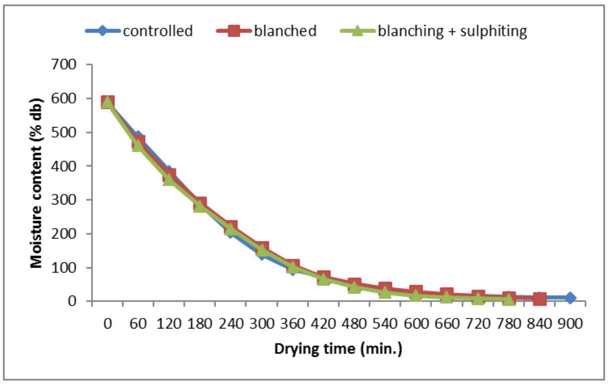

Fig 5: Variation in moisture content with drying time for aonla shreds under hot air oven at 70^{0}C.

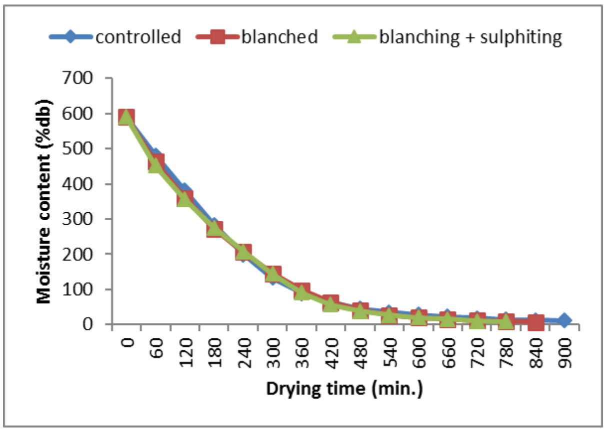

Fig 6: Variation in moisture content with drying time for aonla shreds under hot air oven at 80^{0}C.

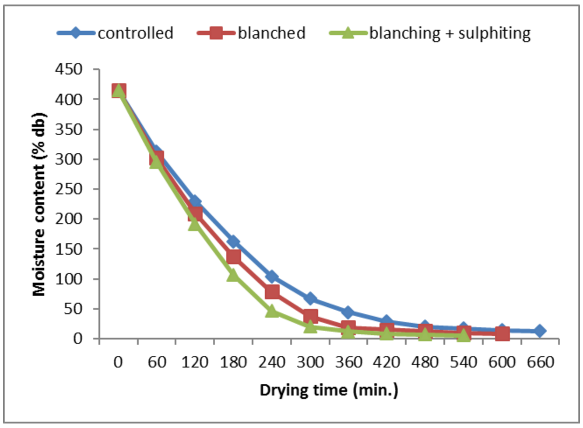

Fig 7: Variation in moisture content with drying time for aonla shreds under osmo-air drying at 60^{0}C.

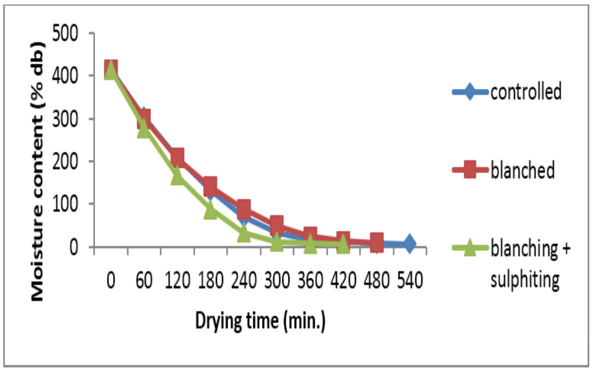

Fig 8: Variation in moisture content with drying time for aonla shreds under osmo-air drying at 70^{0}C.

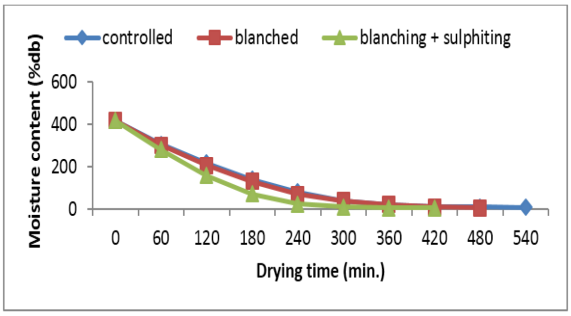

Fig 9: Variation in moisture content with drying time for aonla shreds under osmo-air drying at 80^{0}C.

Drying rate: The drying rate represents the rate of change of moisture content (% d.b.) over a particular time interval. It can be expressed in % db/min as shown in fig 10 to 18. The drying rate at higher temperature is larger as compare to lower temperature and decrease with drying time. The drying rate of controlled, blanched and blanched + sulphiting sample at 60ºC, 70ºC and 80ºC under cabinet tray dryer was1.302%, 2.183% and 2.298%; 1.532%, 2.41% and 2.56%; 1.724%, 1.99% and 2.68% and was reduced to 0.0766%, 0.0763% and 0.0756%; 0.057%, 0.095% and 0.114%; 0.0957%, 0.0574% and 0.0191% at last. Initially the average drying rate decreases rapidly with temperature and as the time progresses the rate becomes slower and slower thereafter. For hot air oven drying the drying rate of controlled, blanched and blanched + sulphiting sample at 60ºC, 70ºC and 80ºC was found 1.53%, 1.91% and 2.03%; 1.72%, 1.95% and 2.14%; 1.800%, 2.107% and 2.298% and was reduced to 0.019%, 0.038% and 0.057%; 0.019%, 0.057% and 0.0383%; 0.019%, 0.038% and 0.038%. The drying rate of controlled, blanched and blanched + sulphiting sample at 60ºC, 70ºC and 80ºC under osmo-air drying was 1.718%, 1.89% and 2.00%; 1.86%, 1.91% and 2.29%; 1.83%, 1.90% and 2.26% and was reduced to 0.028%, 0.028% and 0.014%; 0.028%, 0.057% and 0.028%; 0.028%,. 0.051% and 0.026%. The rate of drying was affected by temperature and treatment. The decrease in drying rate with the period of drying was non-linear. But at few points there was unexpected interaction of curves and this was due to experimental variations. The internal mass transfer was there by molecular diffusion or vapours diffusion or by capillary forces in the interior region of the product and the water was evaporated as it reached the surface. The drying in falling rate period indicates that, internal mass transfer occurred by diffusion. Similar results have been reported for the drying studies on onion slices (Rapusas and Driscoll, 1995) [11] and apricots (Doymaz, 2004) [4].

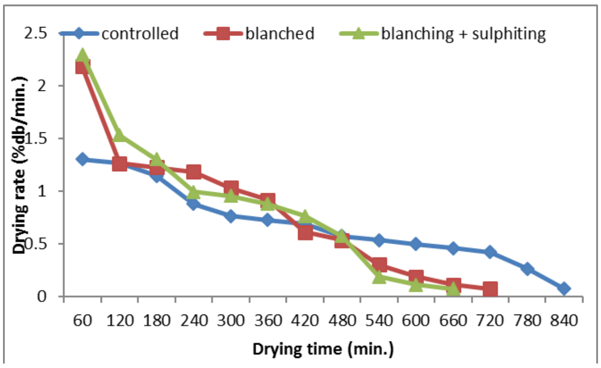

Fig 10: Variation in drying rate with drying time for aonla shreds under cabinet tray dryer at 60^{0}C.

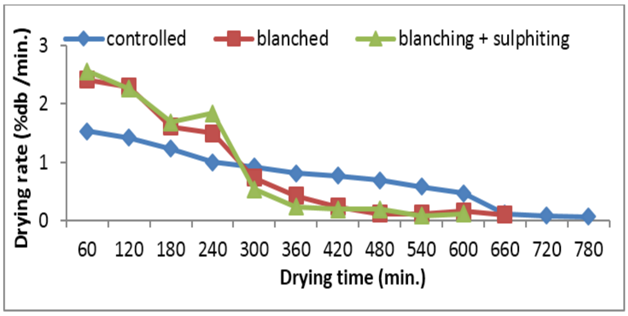

Fig 11: Variation in drying rate with drying time for aonla shreds under cabinet tray dryer at 70^{0}C.

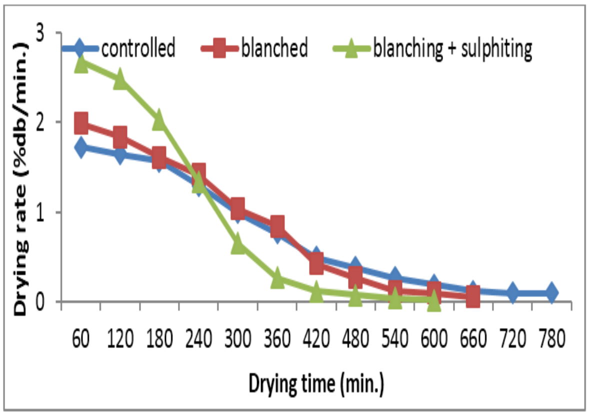

Fig 12: Variation in drying rate with drying time for aonla shreds under cabinet tray dryer at 80^{0}C.

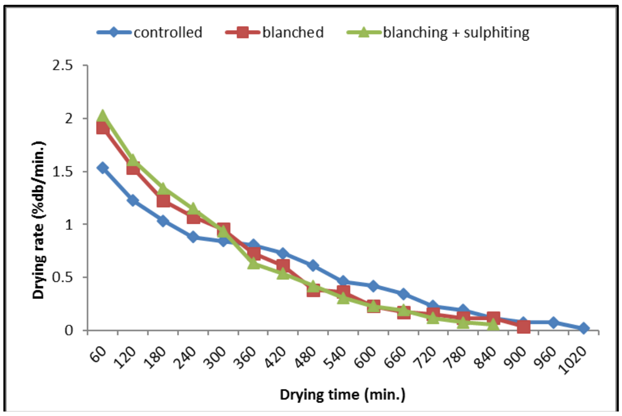

Fig 13: Variation in drying rate with drying time for aonla shreds under hot air oven at 60^{0}C.

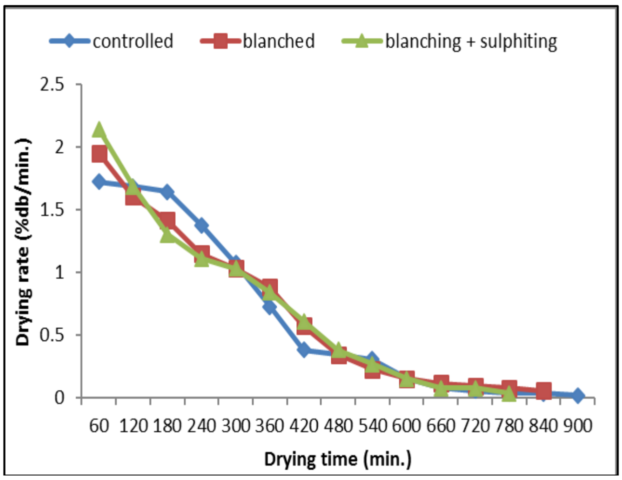

Fig 14: Variation in drying rate with drying time for aonla shreds under hot air oven at 70^{0}C.

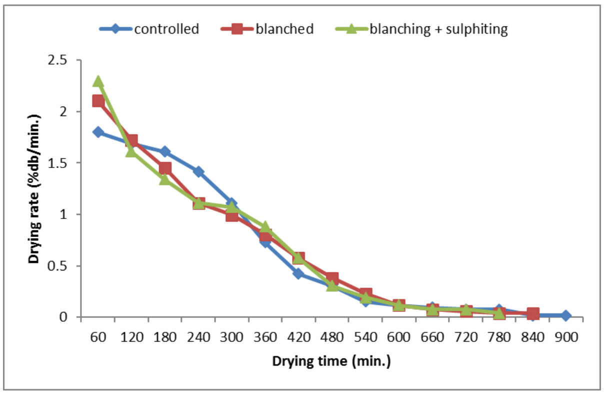

Fig 15: Variation in drying rate with drying time for aonla shreds under hot air oven at 80^{0}C.

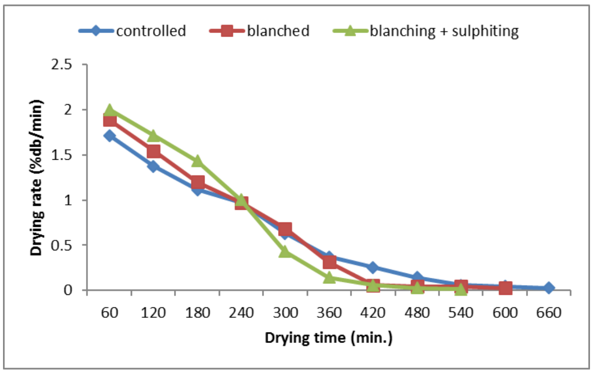

Fig 16: Variation in drying rate with drying time for aonla shreds under osmo-air drying at 60^{0}C.

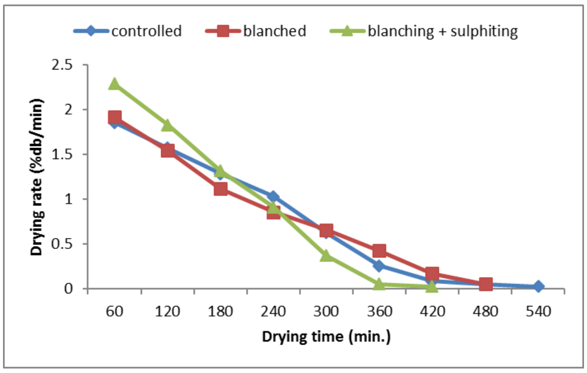

Fig 17: Variation in drying rate with drying time for aonla shreds under osmo-air drying at 70^{0}C.

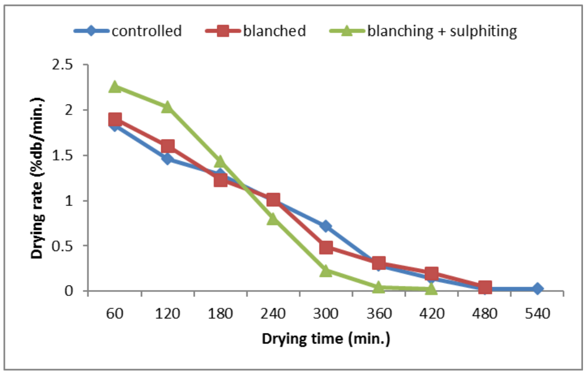

Fig 18: Variation in drying rate with drying time for aonla shreds under osmo-air drying at 80^{0}C.

Conclusion

The samples were dried from initial moisture content of 415.46-589.66 % (db.) to the final moisture content of 5.37 – 12.64 % (db). There is a nonlinear decrease of moisture content with drying time. Initially the moisture content decreases rapidly with time and there after it becomes slower and slower. In the fallen rate period, the material surface was no longer saturated with water and drying was controlled from diffusion of moisture from the interior of the material to the surface. Initially the drying rate decreases rapidly with temperature and as the time progresses the rate becomes slower and slower thereafter. Constant rate drying period was absent throughout the drying process of aonla shreds dried under all drying air temperature. Major drying took place in fallen rate period. It was observed that total moisture loss increased with increase in drying temperature and decreased with decrease in drying temperature. Osmosis as a pretreatment prior to convective air drying was able to decrease drying time. The blanching + sulphiting aonla shred samples with osmotic pre-treatment were more appreciable in comparison to controlled and blanched aonla shred under cabinet tray dryer and hot air oven dryer on the basis of moisture content and drying rate.

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