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Refractance Window Drying vis-à-vis Osmotic and Hot Air Drying of Indian Gooseberry based: Comparison of Quality Attribute and Microstructural Changes

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ABSTRACT: Amla or Indian gooseberry is a medicinal fruit native to India with good commercial value. Due to high ascorbic acid and total polyphenols contents, amla is considered a good source of antioxidants. However, these constituents are sensitive to heat. In this investigation, the effect of refractance window (RW) drying, osmotic dehydration (OD) and hot air drying (HA) on retention of heat sensitive compounds and changes in microstructures of dehydrated amla slices were compared in order to find out the suitable drying technique for amla fruits. The RWD process retained significantly higher content (4-6 %) of heat sensitive compounds compared to OSD and HAD samples. The refractance window dried samples had also a smoother and uniform microstructure. Cell structures were formed in layers in OSD sample indicating case hardening, whereas extensive collapse in cell structure was observed in case of HAD sample. The RW drying is best suitable for preserving heat sensitive compound in aonla.

Keywords: Amla, Ascorbic acid retention, Phenolic content, SEM.

INTRODUCTION

Indian gooseberry (*Emblica officinalis* Gaertn.), commonly known as *amla* or *aonla*, is widely grown in tropical and subtropical regions like India, Malaysia, Nepal, China, and Indonesia. India is largest producer of amla, which produces approximately 1075 MT per year in an area of 95 thousand hectares. But India does not hold first position in largest exporter of amla, this place is hold by the Canada followed by Thailand and Peru. The Asia Pacific region is hub for the global Indian Gooseberry market. A substantial amount of amla and amla puree are exported from India to countries such as Malaysia, Japan, United States of America, Nepal and Bangladesh (Anonymous, 2023). A large portion of amla grown in India is processed into value-added products such as pickles, candy, jam, murabba, juice, etc. In addition to it, drying is most common and widely used techniques for transforming raw produce into the value-added products by removing the excess water and prevent from the microbial attack; and preserve for very long duration. Dried amla is useful in haemorrhages, diarrhea, dysentery, anaemia, jaundice, dyspepsia and cough and used in the indigenous medicines (Aurvedic system) *viz*., *triphala* powder and *chavanprash* (Anonymous, 2022). While, reviewing the literature for the present study, it has been found that amla is dried by various drying techniques *viz*., hot air drying (Prajapati *et al*., 2011; Sonkar *et al*., 2020), osmotic dehydration (Alam *et al.*, 2010), solar drying (Patil and Gawande 2018), Fluidized bed drying (Murthy *et al.*, 2007), freeze-drying and oven drying (Mishra *et al*., 2009). Among all these drying techniques hot air drying is predominately used for amla drying, but it has a great disadvantage of the energy inefficiency and direct exposure of hot air to the product which deteriorates the nutritional quality of product to grater extend. In contrast to this drying technology, freeze drying is superior technology in order to preserve the nutritional constituents but it also has a limitation, being expensive and poor energy efficient.

As an alternative to the HAD and FD, refractance window (RW) drying is looked upon as promising drying technique and prevent thermal degradation of heat sensitive nutritional constituents. Several researchers such as kiwi (Jafari *et al.*, 2016), tomato (Abul-Fadl and Ghanem 2011; Abbasid *et al.*, 2015), pomegranate (Baeghbali *et al.*, 2016), mango (Shende and Datta 2019) were carried out for preservation of heat sensitive compounds using RW drying. Due to such quality of refractance window (RW) drying techniques, it is gaining it importance and in last two decades RWD was explored for many agricultural commodities. However, no work has been reported to explore the potential of RWD for the production of dried amla slices. Therefore, the objectives of this study were to exploration of RWD technique for amla and its comparison with the hot air drying (AD) and osmotic dehydration (OD).

MATERIALS AND METHODS

Amla (Var. - *Banarasi*) used for the study were procured from the Farm Section of ICAR- Central Institute of Agricultural Engineering, Bhopal. The sorting of fruit was done manually to ensure that there was no cutting or any sign of physical injury. Afterward, amla fruits were sliced into 4 mm thickness and dried under Refractance window dryer, hot air and osmotic dehydration. For refractance window drying process, a batch-type laboratory-scale RW dryer was operate at 82° water temperature. The process parameters for OD were taken from Alam *et al.* (2010), under which sugar concentration was 59 °Brix, solution time was 60 min and solution were temperature 51 °C and for air drying the temperature of air was 82°. The drying was continued until the constant weight was obtained. The dried sample was analysed for the phenolic content, ascorbic acid content, colour change and browning index.

Total Phenolic content: One gram of dried amla was refluxed with 5 ml of 80% methanol. 0.2 ml of extract with 1.8 ml of distilled water was added with 10 ml of Folin's Regent (10 fold dilute). After 5 min 8 ml of saturated solution of Na_2CO_3 was added and reaction mixture was incubator for 1 hr at room temperature. The absorb blue color was read at 760 nm against blank. The concentration of total phenolic content were determined from standard curve prepared simultaneously using gallic acid (Singleton *et al.*, 1999).

$$\text{Phenol conc.}\left(\frac{\text{mg}}{100\text{ g}}\right) = \frac{\text{phenol value from graph} \times \text{final vol. made} \times 100}{\text{wt. of sample} \times \text{aliquate}}$$

Ascorbic acid: Five gram of dried amla was mixed with 40 ml distilled water and filtered through muslin cloth. Afterward, the solution was centrifuged at 7000 rpm for 10 min and supernatant was collected. From the extract, 10 mL was taken into test-tube and 2 mL of trichloro acetic acid (10%) was added to it and put inti ice bath for 10 min. Further 2 mL of Folin's Regent (10 fold dilute) was added to the solution and absorbance was measured at 760 nm (Rajoriya *et al.,* 2019).

***Colour change and Browning index*:** The color and browning index of dried amla was estimated by the image captured under contestant illumination. Further, using image processing tool box of MATLAB was utilized for the L, a and b values. The change in color (ΔE) and browning index (BI) was calculated by following equations:

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$$

$$BI = \frac{100\,(x - 0.31)}{0.17}$$

$$x = \frac{a + 1.75L}{5.645L + a - 3.012b}$$

Scanning electron microscopy: Powders obtained from RWD, AD and OD were morphologically characterized by scanning electron microscopy (ZEISS ULTRA Plus, Germany).

RESULTS AND DISCUSSIONS

Amla with an initial moisture content of 87 % (w.b.) were dried until a constant weight of the sample was achieved. Fig. 1 shows the drying curves of amla undergoing three different drying methods. It was found that RWD took shortest time to reach the desired moisture content because of a high driving force for mass and heat transfer. Also, the dried matter was observed high in RWD sample with lowest moisture content. However, OD took less time to reach a constant weight compared to the HAD. It may be due to the cash hardening occurred in OD hindered the escape of moisture from the surface to the surrounding and led to the shorter drying time with high moisture content in end product. No significant difference in moisture content was observed between RWD and HAD samples.

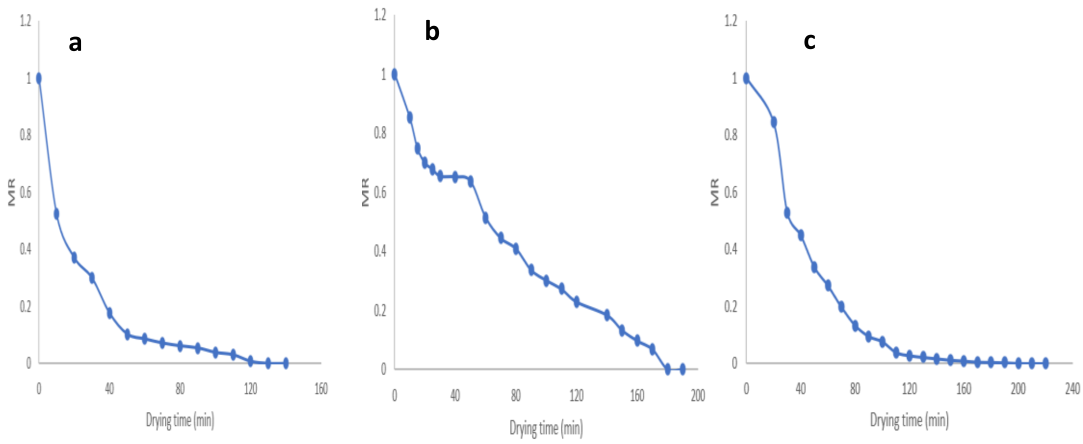

Fig. 1. Drying curves for amla (a) RW, (b) OD and c) HA.

The quality evaluation of dried amla obtained from RWD, OD and HA was done on the basis of ascorbic acid (AAR), total phenolic content retention (PCR), color change, browning index and change in microstructures.

Highest retention of ascorbic acid content was found in RW dried amla slices followed by OD and HA samples (Table 1). The minimum retention of ascorbic acid and total phenolic content was observed in HA dried sample. It may be because of the direct exposure of hot air for longer drying time resulted in oxidation of the heat sensitive compounds, consequently reducing the nutritional quality. Also, the variation in AAR and PCR may be attributed due to the inactivation of oxidative enzymes and initiation of Maillard reaction. Calderón-Chiu *et al.* (2020) also found that RSA and TPC values were less in OSD sample compared to the RWD. Such difference in OD dried amla samples could be supported by the reduction in the membrane permeability and selectivity, favoring the leaching of these compounds into the osmotic solution. Also, the end product obtained from the OD treatment depends on the proportion of cells altered and non-altered cells (Chiralt and Talens 2005).

The amla slices dried in RW dryer had highest color retention and lower browning index. The effectiveness of RW can be linked to the fact that heat is dispersed like a window across both the surface of the membrane and the volume of the drying slices. When the slices dry out, the heat intensity diminishes, which effectively closes the window at the point when the material is virtually dry and has attained its moisture equilibrium. Hence, the RW approach does not result in the significant reductions in colour. However, in OD, the leaching of solute into osmotic solution also involves the colour pigments and results in change in colour. In mango and paprika puree drying, RWD preserved color better than the HA drying (Topuz *et al*., 2009; Shende and Datta 2020).

Table 1: Quality attribute of dried amla.

Quality Parameter	RWD	OD	AD
AAR (%)	56.24±2.6	51.90±1.57	4.86±1.75
PCA (mg/100g)	241.59±0.86	237.29 ±1.24	231.15 ±1.54
Moisture content (%, db)	4.36±0.12	8.87±1.37	4.54±1.28
Color Change (%)	14.74± 1.40	19.03±1.52	28.23±0.84
Browning index (%)	53.39±0.61	56.15±0.93	60.55±0.51

The study of microstructure changes during drying process was carried out by the scanning Electron Micrograph (Fig. 2). All the three drying conditions affected the microstructure of dried amla, which is shown in Fig. 2. Most porous structure was found in RW dried amla, this could be due to the controlled and uniform heating through mylar sheet. While osmotically dehydrated powder had a higher percentage of moisture than hot air-dried powder, it was discovered that osmotically dehydrated powder had a lower porosity. Osmotically dehydrated powder had layered cell formations caused by the presence of a sugar solute. The amla slices were subjected to direct and ongoing contact with the heating media in air-drying methods which caused a greater degree of shrinkage and cell rapture.

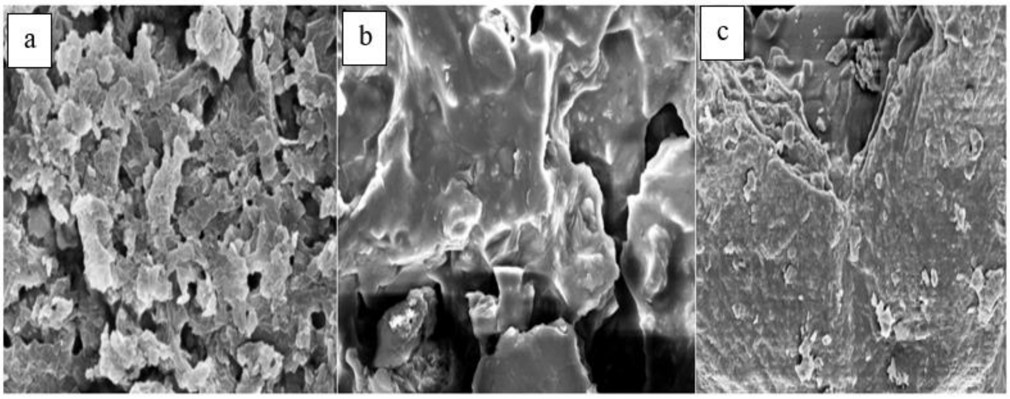

Fig. 2. Scanning Electron Micrograph a) RW, b) OD and c) HA dried amla.

CONCLUSIONS

Drying is one of the most common techniques used for preserving amla, and various techniques like hot air drying, osmotic dehydration, solar drying, fluidized bed drying, freeze-drying, and oven drying have been explored for amla. Refractance window drying (RWD) is an alternative technique that is promising due to its ability to prevent thermal degradation of heat-sensitive nutritional constituents. RWD has potential for producing dried amla products with better retention of heat sensitive compounds with good nutritional properties compared to hot air drying and osmotic drying. Besides, maintaining nutritional qualities, the RW dried amla powder was more porous structure with better color retention. It can be recommended for dehydration of amla slices by RWD.

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