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Drying characteristics of aonla (*Emblica officinalis*) pomace

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Abstract
The increasing consumption of animal products will give rise to a huge demand of animal feed. Meeting this demand will be a challenge, given the scarcity of natural resources such as land and water. The major waste produced includes the organic waste such as peel, stem, core, seeds and pomace. In case of aonla pomace sample, drying time at 45, 55 and 65 °C was 210, 180 and 165 min respectively. Moisture loss was found to be temperature dependent and slow at lower temperature and took more time as compared to drying at higher temperatures. It can also be observed from these curves that the drying time decreased with increase in drying air temperature.

Keywords: Aonla pomace, drying, zinc, waste, drying

Introduction
The scenario of horticulture crops in India has become very encouraging. The share of horticulture output in Agriculture has become 33 per cent. Under the purview of agriculture and allied activities, the share of plan outlay for horticulture which was 3.9 per cent during IX Plan, has increased to 4.6 per cent during the XII Plan (Horticulture Statistics Division, 2018) [3].

India has witnessed increase in horticulture production over the last few years. Significant progress has been made in area expansion resulting in higher production. Over the last decade, the area under horticulture grew by 2.6 per cent per annum and annual production increased by 4.8 per cent. During 2017-18, the production of horticulture crops was 311.71 Million Tonnes from an area of 25.43 Million Hectares. The production of vegetables has also increased from 101.2 Million Tonnes to 184.40 Million Tonnes since 2004-05 to 2017-18 and production of fruits has increased from 50.9 Million Tonnes to 97.35 Million Tonnes since 2004-05 to 2017-18. The production of aonla in the year 2017-18, is 10.75 Lakh Tonnes in the area of 93000 hectare (Horticulture Statistics Division, 2018) [3]. India is the second largest producer of vegetables and fruits and our presence in global market is significant. The different types of fruits are exported. Grapes occupies the premier position in exports with 1.88 Lakh Tonnes. Other fruits which have attained significant position in exports are banana and mango. Fresh vegetable (e.g. onion, peas and potato) exports have been on the rise. The development achieved in the horticulture sector is indicative of the fact that there is growing demand for horticulture produce. The past experiences have been rewarding for enhanced output from the investment. Availability of timely robust information in this sector will certainly improve the socio-economic conditions of Indian citizens by providing self-reliance besides environmental protection.

Phyllanthus emblica (syn. *Emblica officinalis*) colloquially known as the Indian gooseberry (English), amalaka (Sanskrit), and aonla (Hindi) is an important deciduous tree. This plant was originally native to India but is today found growing in Pakistan, Uzbekistan, Sri Lanka, Southeast Asia, China, and Malaysia (Mirunalini and Krishnaveni, 2010) [4].

Aonla well known for its nutritional qualities. It is rich in polyphenols, minerals and regarded as one of the richest source of vitamin C (200-900 mg/100 g of edible portion), has superior value in entirely indigenous traditional system of medicine (Variya *et al*. 2016) [6].

Fruits and vegetables are the most utilized commodities among all horticultural crops. They are consumed raw, minimally processed, as well as processed, due to their nutrients and health-promoting compounds.

With the growing population and changing diet habits, the production and processing of horticultural crops, especially fruits and vegetables, have increased very significantly to fulfil the increasing demands. Significant losses and waste in the fresh and processing industries are becoming a serious nutritional, economical, and environmental problem. For example, the United Nations Food and Agriculture Organization (FAO) has estimated that losses and waste in fruits and vegetables are the highest among all types of foods, and may reach up to 60 per cent. The processing operations of fruits and vegetables produce significant wastes which constitute about 25 per cent to 30 per cent of a whole commodity group (Sagar *et al*. 2018) [5].

In comparison with other fruits like apple, the edible fruit tissue of aonla is rich with proteins 3-fold and ascorbic acid 160-fold and contains considerably higher concentration of most minerals and amino acids. Pulpy matter of fruit, after drying found to contain: gallic acid 1.32 per cent, tannin, gum 13.75 per cent; albumin 13.08 per cent; crude cellulose 17.08 per cent; mineral matter 4.12 per cent and moisture 3.83 percent (Charmkar and Singh, 2017) [2].

Materials and Methods

Materials

Aonla was procured from nearby market and sorted good quality fruits from defects and washed thoroughly three to four times under tap water to remove adhering impurities. After washing peeling and trimming was done followed by grinding and filtration after that aonla juice is separated from pomace.

Methods

Drying of aonla pomace

The moisture content of fresh amla pomace was calculated before drying by using hot air oven (AOAC, 2000) [1] method. Fresh aonla pomace was spread on the rectangular shaped tray in tray dryer. Tray dryer was stabilise prior to commencement of reading. The product was weighed periodically to calculate the loss in weight. Drying was done at 45 ℃, 55 ℃ and 65 ℃ at constant air velocity 2 m/s. The dried aonla pomace was then powdered by grinder.

Results and Discussion

Effect of temperature on moisture content

The change in moisture content of aonla pomace with elapsed drying time, at each of drying temperature 45, 55 and 65 ℃ at air velocity of 2 m/s are presented in following figure. The moisture content of aonla pomace decreased exponentially with drying time under all drying temperatures. The drying followed a typical trend of drying behaviour for food materials as reported by Singh, 2001 [2]. As the drying air temperature increased, the drying curves exhibited steeper slope indicating that the drying rate increased with increase in drying air temperature. This resulted into substantial decrease of drying time. In case of aonla pomace sample, drying time at 45, 55 and 65 ℃ was 210, 180 and 165 min respectively. The average initial moisture content of the aonla pomace was 250.88 per cent (db) and the final moisture content was found in the range of 7.09 to 7.23 per cent (db).

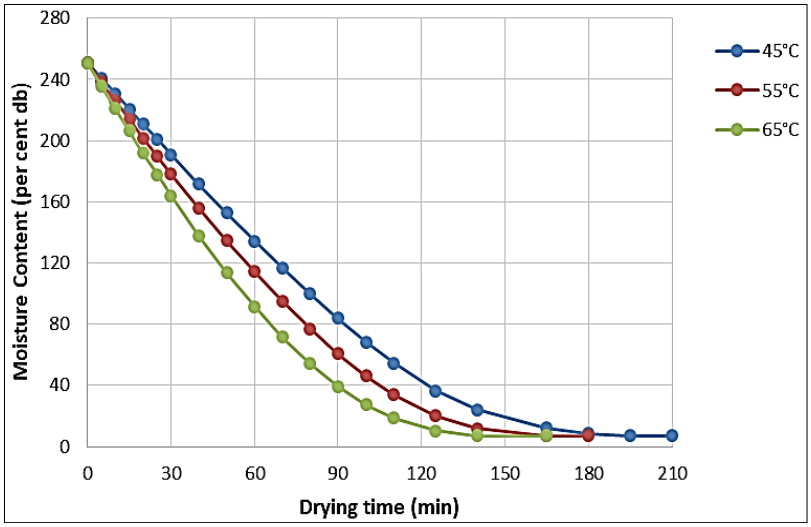

Fig 1: Variation in moisture content of aonla pomace with time at 45, 55 and 65 ˚C drying temperature

It can be seen that the variation in drying time from 165 to 210 min for the range of drying air temperatures 45 to 65 ℃. Moisture loss was found to be temperature dependent and slow at lower temperature and took more time as compared to drying at higher temperatures. It can also be observed from these curves that the drying time decreased with increase in drying air temperature. Hence, experimental results showed that the drying air temperature has effect on the removal of moisture content. It can also be seen that minimum time for drying was observed for higher air temperature (65 ℃) and maximum time was recorded for lower air temperature (45 ℃). The drying time observed under various drying temperature is presented.

Effect of temperature on drying rate of aonla pomace

The drying rate for the aonla pomace was estimated from the difference in its moisture loss in a known time interval and expressed as g of moisture evaporated per g of dry matter per min. The drying rate of aonla pomace under different tray drying temperature were calculated and plotted with moisture content presented in following figure.

It can be seen that the drying rate subsequently reduced with drying time. It can also be seen that drying rate follow typical drying rate curves. The drying rate for aonla pomace sample was observed at initial stage of drying 0.0203, 0.02477 and 0.029825 g-water/ g-dm-min at 45, 55 and 65 ℃ of drying air temperature respectively. These drying rates continuously decreased with respect to time.

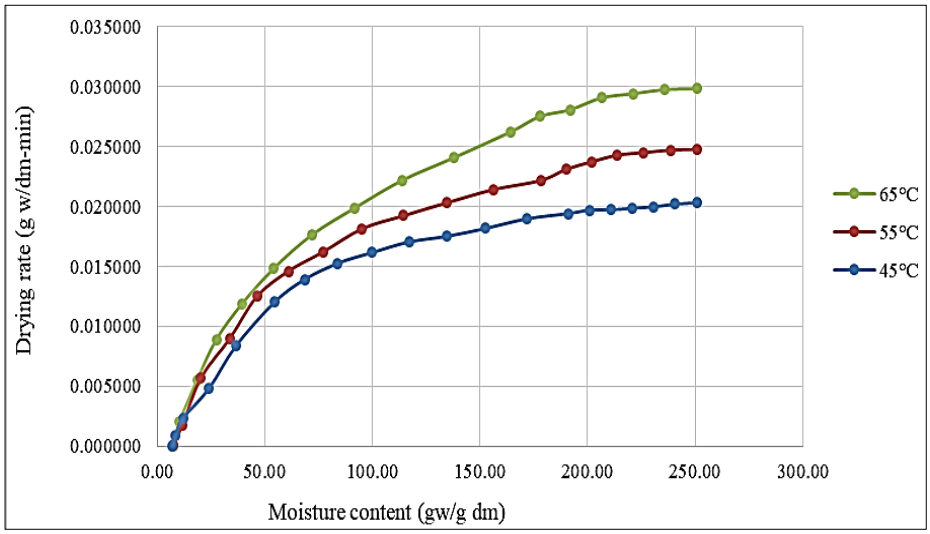

Fig 2: Variation in drying rate of aonla pomace with moisture content at 45, 55 and 65 °C drying temperature

From the observation it can be seen that, a constant rate-drying period was not found in drying curves. The entire drying process took place in the falling rate period; the curves typically demonstrated smooth diffusion controlled drying behaviour under all drying temperatures. Moreover, an important influence of air drying temperature on drying rate could be observed in these curves. It is obvious from these curves that the higher the drying temperature, the greater the drying rate, so the highest values of drying rate were obtained during the experiment at 65 ºC.

Conclusion

The total drying time was reduced by 14.28 per cent on increasing the air temperature from 45 ℃ to 55 ℃. Similarly the reduction in the total drying time on increasing the temperature from 55 ℃ to 65 ℃ was 8.33 per cent. And the total reduction in time on drying air temperature at 65 ℃ as compared to 45 °C temperature is by 21.42 percent.

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